Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

CHNOLOGY DEPARTMENT
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MAY, 1947

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DETROIT

LEWIS ROLLS

...HELP MAINTAIN PEAK PRODUCTION OF ROLLED METALS

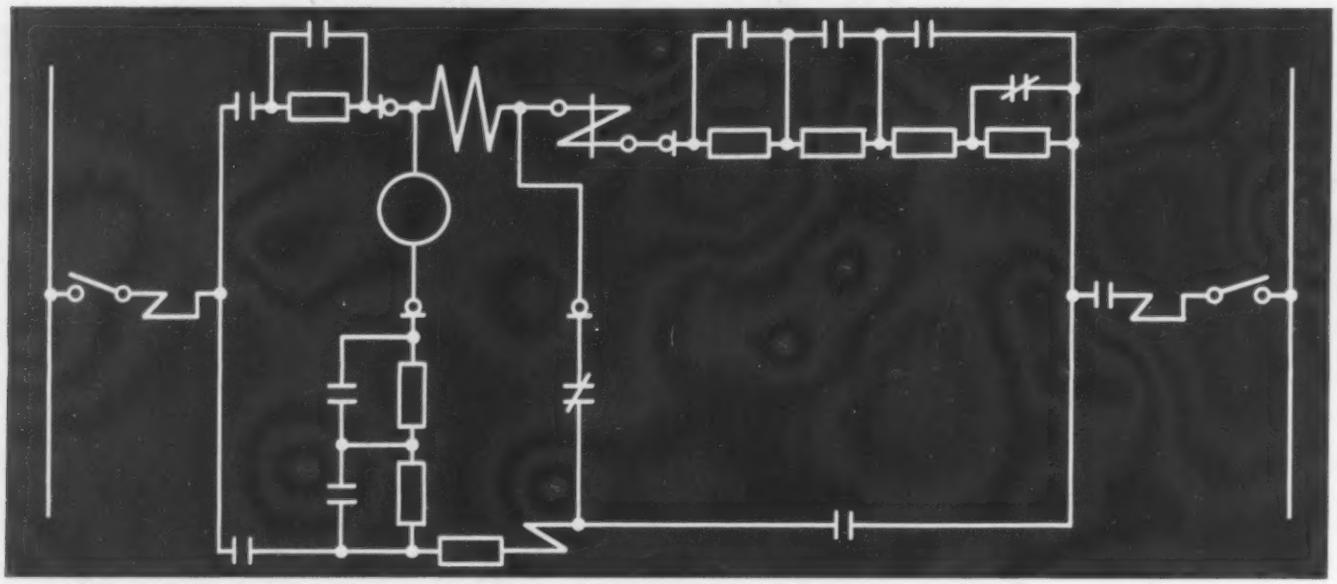
LEWIS FOUNDRY & MACHINE
DIVISION OF BLAW-KNOX COMPANY
PITTSBURGH, PA.

ALSO MANUFACTURERS OF
ROLLING MILL MACHINERY
FOR THE IRON, STEEL AND NON-FERROUS INDUSTRIES

What control for what mill equipment?

One of a SERIES of advertisements featuring basic heavy duty power circuits . . . and showing Cutler-Hammer's broad design and application experience which has made it *the* preferred control for the steel industry.

D.C. dynamic braking hoist control



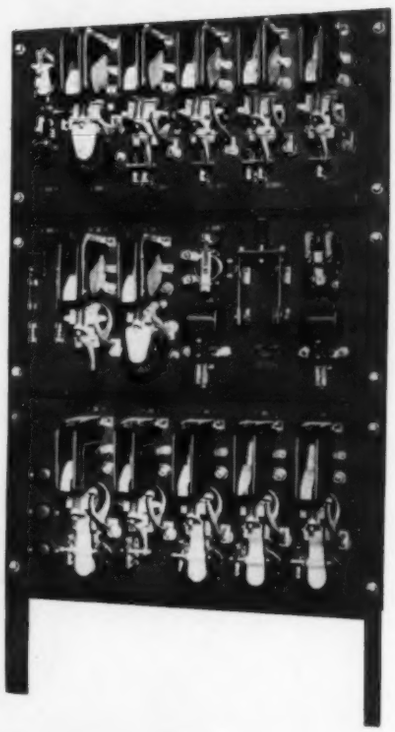
When you have an installation such as a crane hoist or winch where the load may be overhauling and requirements dictate a series motor with dynamic braking . . .

Here . . . use Cutler-Hammer No. 14115 Control

Lt1 ACCELERATION and DECELERATION . . Cutler-Hammer Bulletin No. 14115 provides 5-point inductive time limit acceleration in the hoisting direction for smooth swift take-up of cable slack, equally smooth acceleration and hoisting of loads with a choice of five speeds. Bulletin 14115 also provides inductive time limit acceleration and deceleration in the lowering direction for full speed and safety in lowering all loads and high speed lowering of the empty hook. It provides off-position dynamic braking to assist magnetic brake in stopping the load. It prevents excessive current peaks. It employs dependable constant timing Lt1 contactors which have a coarse and micrometer timing adjustment, not affected by dust and dirt. It is simple, always provides smooth, uniform response to the master, and is trouble-free. Inductive time limit control is another Cutler-Hammer "original' which has been copied but never equalled.

EQUIPMENT . . . Conforming to NEMA standards. Available in ratings up to 1800 amperes—open or enclosed. Also a complete line of control accessories.

VITAL ENGINEERING EXPERIENCE . . . When you specify Cutler-Hammer control for your cranes, ore bridges, etc., you specify more than the physical components. You benefit by a 50-year background of broad and exhaustive experience among the steel mills of America, assuring correct design, and world-famous dependability. CUTLER-HAMMER, Inc., 1269 St. Paul Ave., Milwaukee 1, Wis. *Associate:* Canadian Cutler-Hammer Ltd., Toronto.



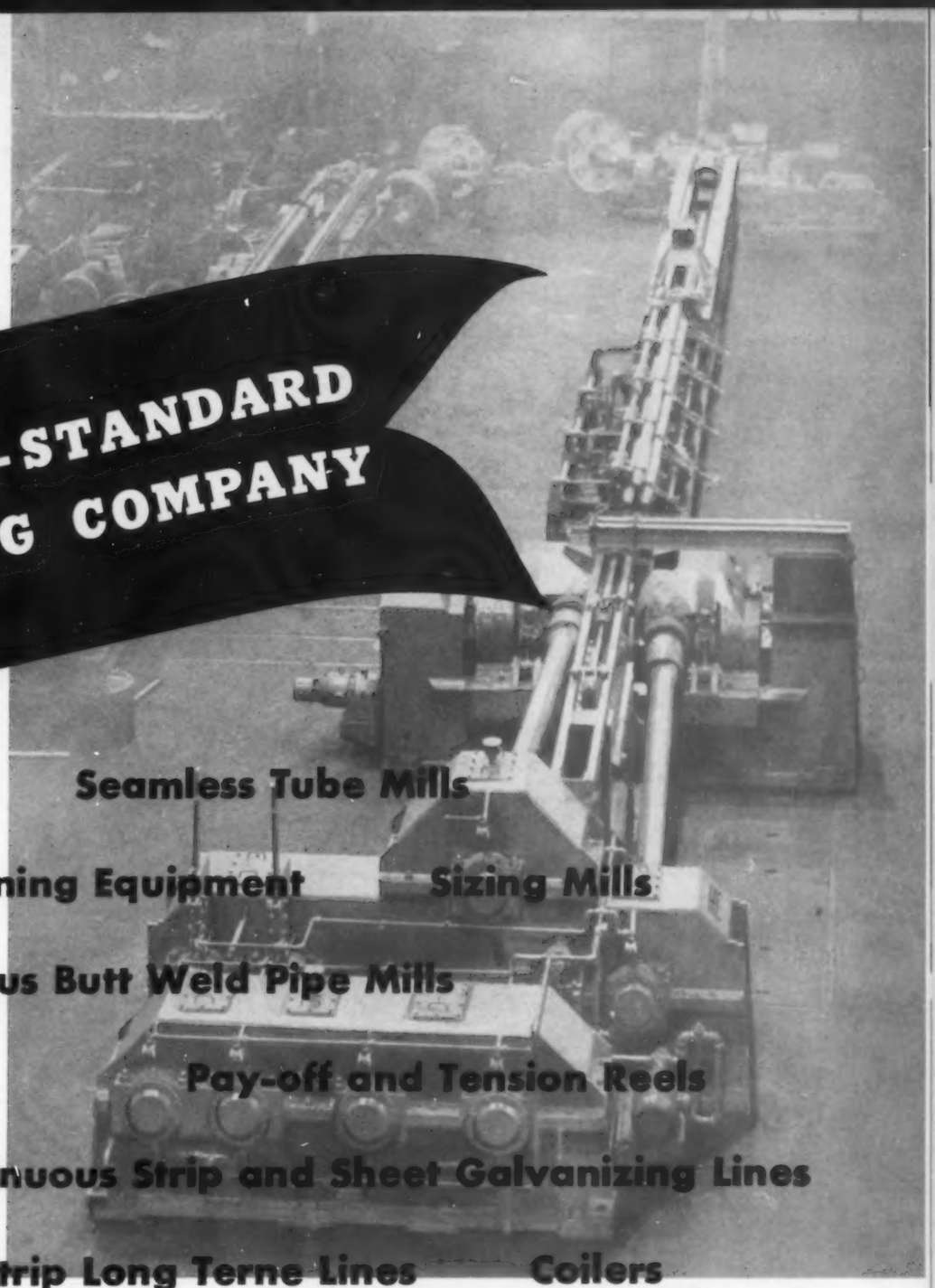
TYPICAL COMPONENTS of CUTLER-HAMMER MILL CONTROL

Crane Safety Limit Stop
Snap action, low headroom. Totally enclosed tripping mechanism, operating lever and tripping weight combined. Mountable in 4 quadrants.

Mill Brake
The simplest, hence the most direct, hence the most efficient of all mill brakes. Hardened steel wheels ground to smooth finish.

Lifting Magnets
Vacuum impregnated with special Cutler-Hammer high temperature compounds. Strap-wound coils. Watertight sealing disk, waterproof terminal box.

CUTLER-HAMMER
MOTOR CONTROL
C-H



THE AETNA-STANDARD ENGINEERING COMPANY

Seamless Tube Mills

Tinning Equipment **Sizing Mills**

Continuous Butt Weld Pipe Mills

Pay-off and Tension Reels

Continuous Strip and Sheet Galvanizing Lines

Continuous Strip Long Terne Lines **Coilers**

Levellers **Mill Tables** **Piercing Mills**

Plug Mills **Rolls**

Slitting Lines

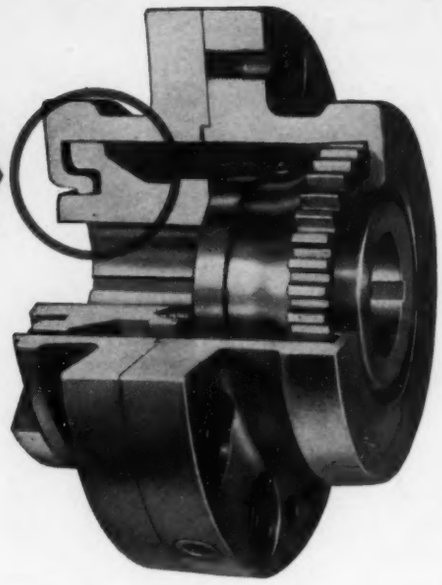
DESIGNERS AND BUILDERS to the Steel, Non-Ferrous and Chemical Industries

THE AETNA-STANDARD ENGINEERING COMPANY

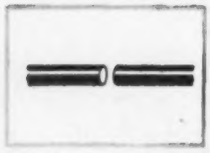
YOUNGSTOWN, OHIO

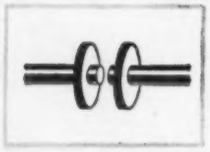
ASSOCIATED COMPANY: HEAD, WRIGHTSON & COMPANY, LTD., MIDDLESBROUGH, ENGLAND

Specify FAST'S—Get This EXTRA Protection *Against* COUPLING SHUTDOWNS



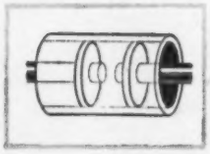
Metal-to-Metal Seal Keeps Oil Clean for Continuous Service!

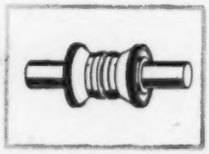


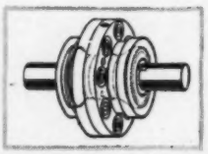


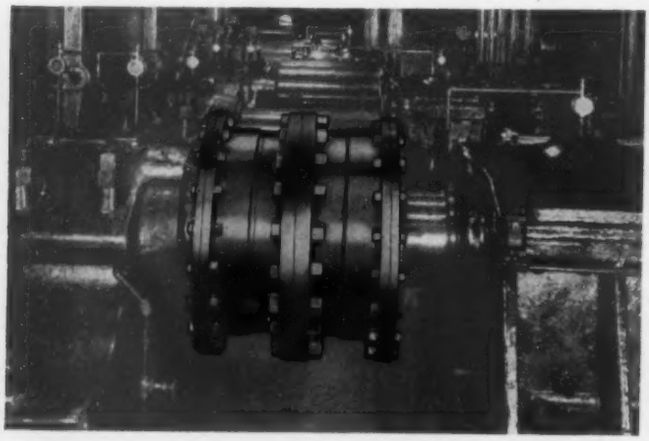
Fast's Couplings Are Simple as A-B-C

See the simple development of Fast's Couplings. A splined hub on each shaft end, a sleeve with internal splines to mesh. Oil in the sleeve carries the load between the splines.









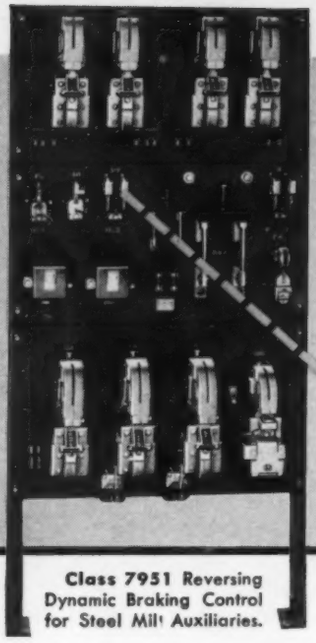
THESE FAST'S HEAVY-DUTY COUPLINGS are installed at the Irwin Works of Carnegie-Illinois Steel Corp.

You can trust Fast's, the *original* gear-type coupling, which eliminated the need for *perishable* parts! The load-carrying oil in a Fast's Coupling is guarded by a positive metal-to-metal seal . . . the *exclusive* "rocking bearing" shown in the circle. The oil is kept free of moisture, dust and grit. No perishable packing rings are used. That's why you get *uninterrupted* power transmission with Fast's.

When you buy Fast's Couplings, you buy many years of top engineering experience, Koppers' high standard of workmanship and unexcelled coupling service. It will pay you to install Fast's . . . for longer machine life, lower upkeep costs, minimum shutdown losses. Write today for our complete catalog to: Koppers Company, Inc., Fast's Coupling Dept., 215 Scott St., Baltimore 3, Maryland.

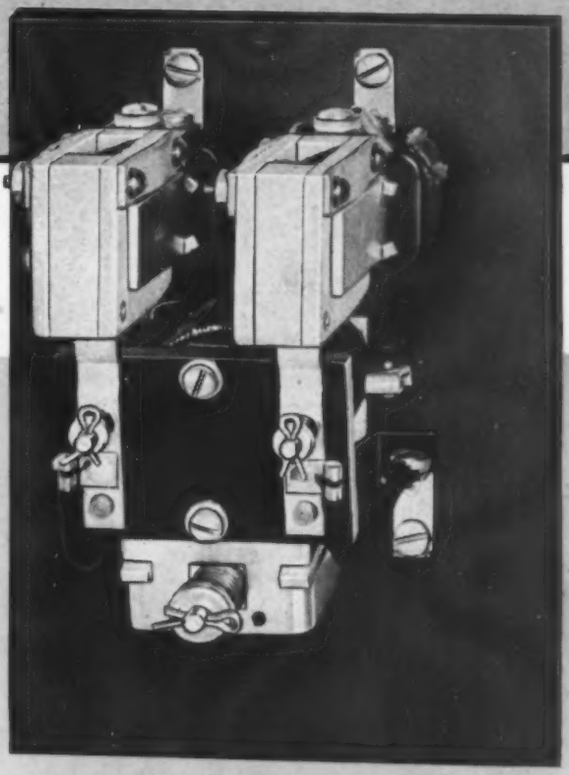
K KOPPERS

FAST'S *self-aligning* COUPLINGS



Class 7951 Reversing Dynamic Braking Control for Steel Mill Auxiliaries.

SQUARE D MILL CONTROL HAS HEAVY DUTY CONTROL RELAYS



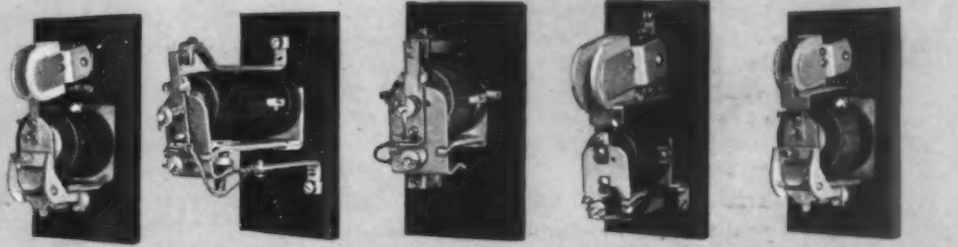
• Controls for D. C. Mill Auxiliaries are required to have contactors of heavy duty construction capable of consistent performance under difficult and severe service conditions. But it is equally important that the relays which control contactor sequence have similar construction. Note these construction features in Square D's control relays . . . they provide another reason for specifying Square D.

15 ampere silver-to-silver contacts • Powerful blowout coils • Effective arc barriers • Frictionless knife-edge bearings • Strong return springs • Low inertia moving parts • Magnet coils suitable for wide voltage range.

UNDERVOLTAGE RELAY of heavy construction used on all Square D Mill Control equipment.

SHUNT FIELD and ARMATURE CONTROL RELAYS

are required for close control and reliable sequencing. Square D builds them all and in the same Heavy Duty construction.



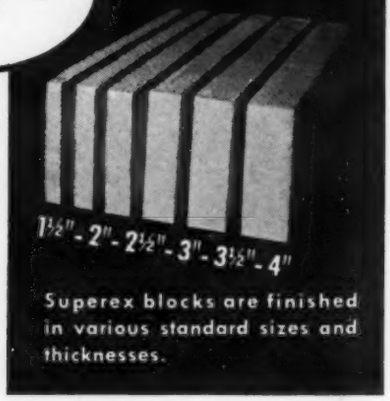
Field Accelerating Relay | Field Loss Relay | Plugging Relay | Anti-Plugging Relay | Field Decelerating Relay

Write for information on the CLASS 7950 SERIES Heavy Duty D. C. Control for cranes and mill auxiliaries and CLASS 9003 Master Switches. SQUARE D COMPANY, 4041 N. Richards Street, Milwaukee 12, Wisconsin.

SQUARE D COMPANY

DETROIT • MILWAUKEE • LOS ANGELES

YES, for over 20 YEARS SUPEREX has never been surpassed



Superex blocks are finished in various standard sizes and thicknesses.

SUPEREX is industry's leading block insulation . . . in hot blast stoves, mains, bustle pipes, kilns, regenerators, roasters, high temperature mains, flues, stacks, industrial and metallurgical furnaces, stationary and marine boilers and auxiliary power plant equipment—wherever the insulation must withstand temperatures up to 1900 F behind a refractory lining.

These seven reasons will tell you why:

1. Low Thermal Conductivity—Superex is made from specially selected calcined diatomaceous silica, bonded with asbestos fibre—presenting a formidable barrier to the passage of heat.

2. High Heat Resistance—J-M Superex Blocks safely withstand temperatures up to 1900 F without deterioration.

3. Light Weight—Approximately 24 lbs. per cu. ft.

4. High Physical Strength—Withstands vibration and other physical abuse encountered in normal service. Approximately five tons pressure per square foot are required to compress Superex ½ inch.

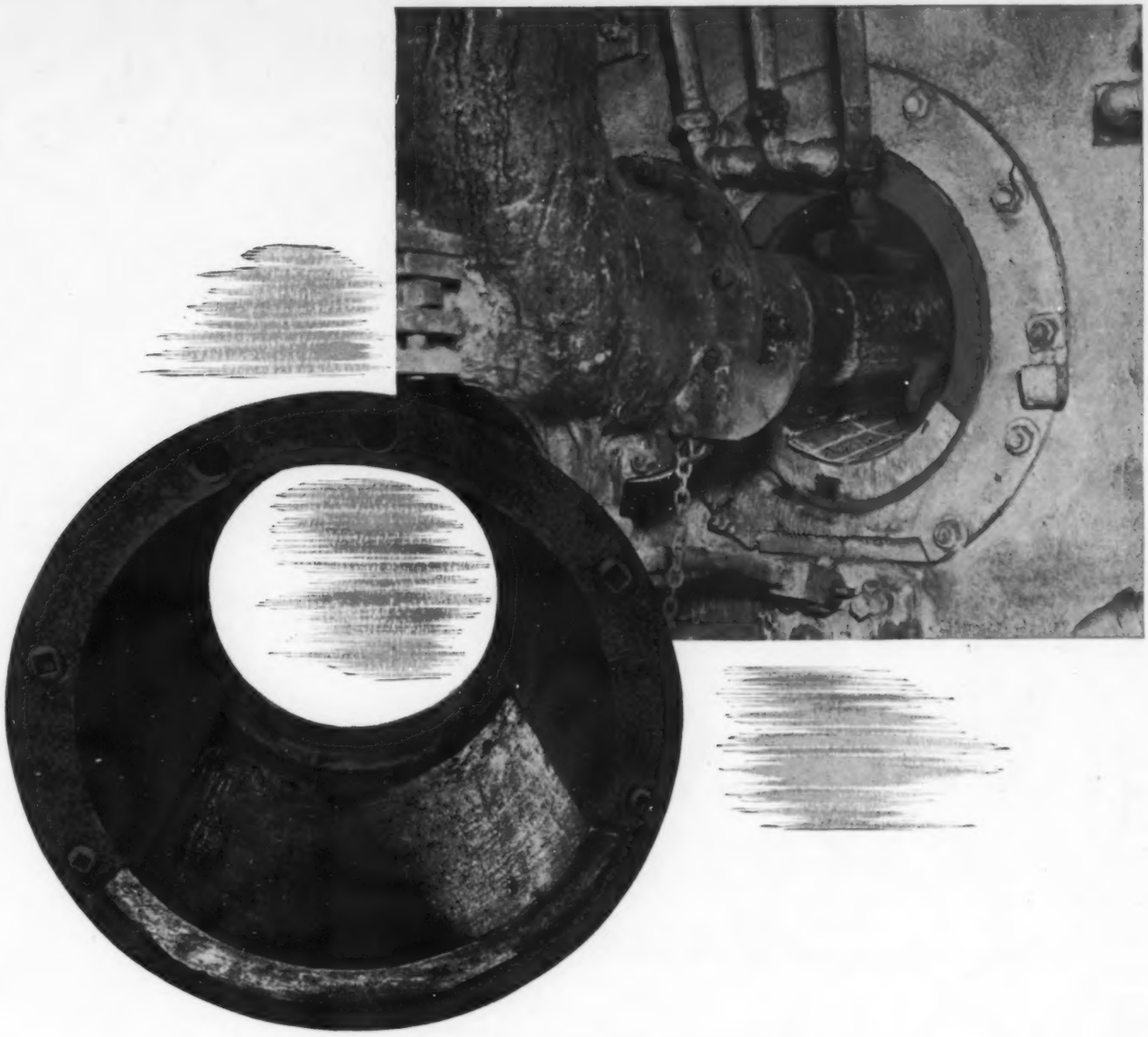
5. Permanent Efficiency—Superex maintains high thermal efficiency indefinitely—will not disintegrate in service for which recommended.

6. Quick Application—The convenient sizes and light weight of Superex assure fast, economical installations.

7. Easy Cutting and Fitting—Superex is easily cut with an ordinary knife or saw for fitting around openings or irregular surfaces.

Special shapes and curved blocks—in addition to the 6 standard thicknesses illustrated—can be supplied. Write Johns-Manville, Box 290, New York 16, N. Y.

JOHNS-MANVILLE *First in* **INSULATIONS**



The New N•B•M Safety Tuyere Cooler

...Protected From Back Flow Damage

By an Apron of Built-in Refractory Lining

If molten iron should run back—it will not cut the cooler.

The narrowed water section speeds up the water flow and prevents clogging by sediment deposits.

The water is directed around the walls to assure better cooling.

Available in all sizes.

May we have your requirements?

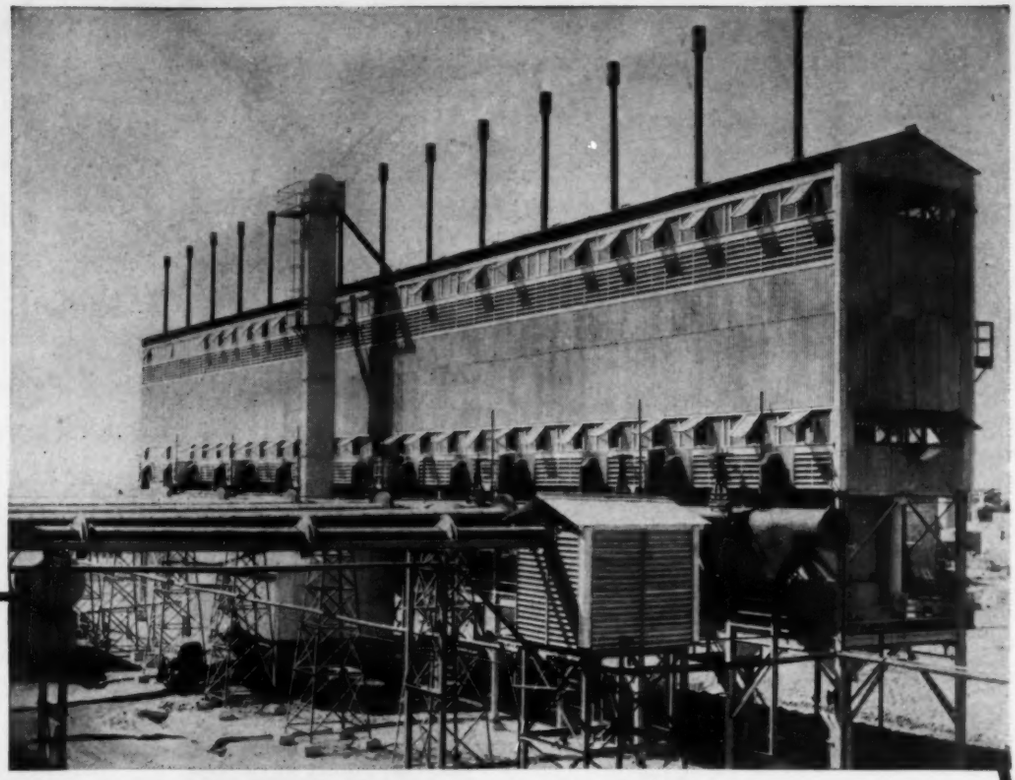
NBM

AMERICAN Brake Shoe COMPANY

NATIONAL BEARING DIVISION

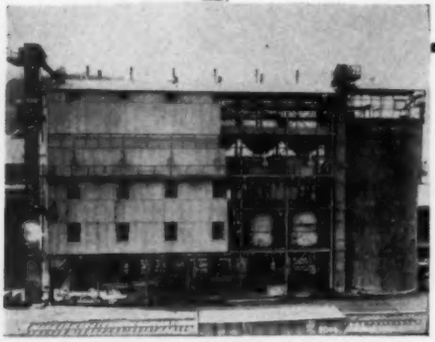
PITTSBURGH • NEW YORK

PLANTS IN: ST. LOUIS, MO • PITTSBURGH, PA. • MEADVILLE, PA. • JERSEY CITY, N. J. • PORTSMOUTH, VA. • ST. PAUL, MINN. • CHICAGO, ILL.

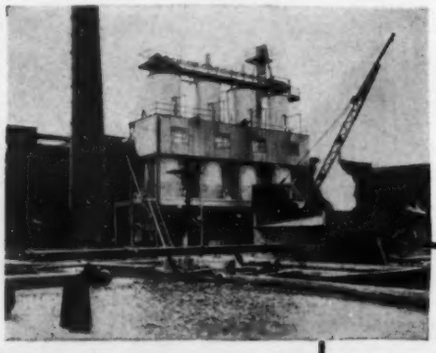


14 largest-size Wellman-Galusha Gas Generators all installed in one building

WELLMAN MANUFACTURES THE FAMOUS *GALUSHA Clean Gas Generators*



6-unit plant of 10' Wellman-Galusha Gas Generators



4-unit plant of Wellman-Galusha Gas Generators

The Wellman-Galusha is a fully water jacketed gas generator with exceptionally efficient rotary grates, ample fuel storage bins and provision for the generation of steam required for gas making—all incorporated in the machine itself.

The lowest priced grades of Anthracite coal, "rice" or smaller, and coke, "pea" or "breeze", can be satisfactorily and economically gasified.

WELLMAN WILL BUILD IT!

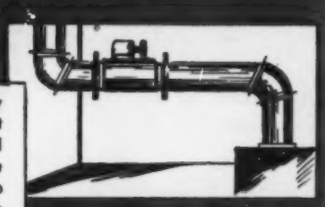
- Car Dumpers (all types)
- Ore and Coal Handling Bridges
- Gas Producers
- Skip Hoists
- Industrial Furnaces
- Coke Pushers
- Mine Hoists
- Charging Machines
- Soaking Pits
- Special Cranes (Wharf, Dry-Dock, Hammerhead, Pontoon)

THE WELLMAN ENGINEERING COMPANY

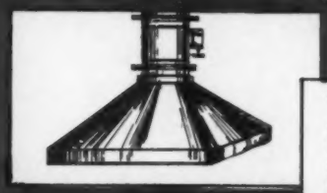
7031 CENTRAL AVENUE • CLEVELAND 4, OHIO

AXIAL FLOW FANS-

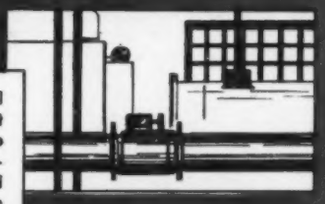
WHEN TO USE THEM TO ADVANTAGE



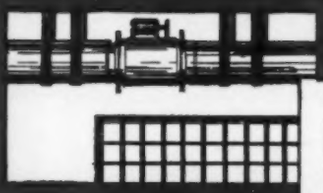
WHEN the fan fits naturally into the middle of a straight duct system. Here the Axial Flow type is installed with the least disturbance, and to special advantage when the system is overhead.



WHEN a vertical air removing system is used — as in exhausting from a hood or paint spray booth—the Axial Flow Fan can be set directly over the opening with the duct straight up.



WHEN space is limited Axial Flow Fans take all straight connections (which take up the least room)—while Centrifugal fans require curved connections, which take up valuable room.



WHEN you have a fan-supporting problem, but still need high air volume. Axial Flows are lighter and smaller than Centrifugals—are more easily supported from ceilings or walls.

Axial Flow Fans fit very well into many industrial and commercial applications where space-saving is important, where an expensive platform can be eliminated, and where straight-line air flow is desirable.

In other cases, they offer no real advantages over Centrifugals and for that reason, Buffalo offers both types.

Bulletin 3533-B gives full details and ratings on Axial Flow Fans. Bulletin 3339 gives the same information on Type LL Centrifugal Fans. Write for copies of both for your files.

BUFFALO FORGE COMPANY

173 MORTIMER STREET BUFFALO, N. Y.

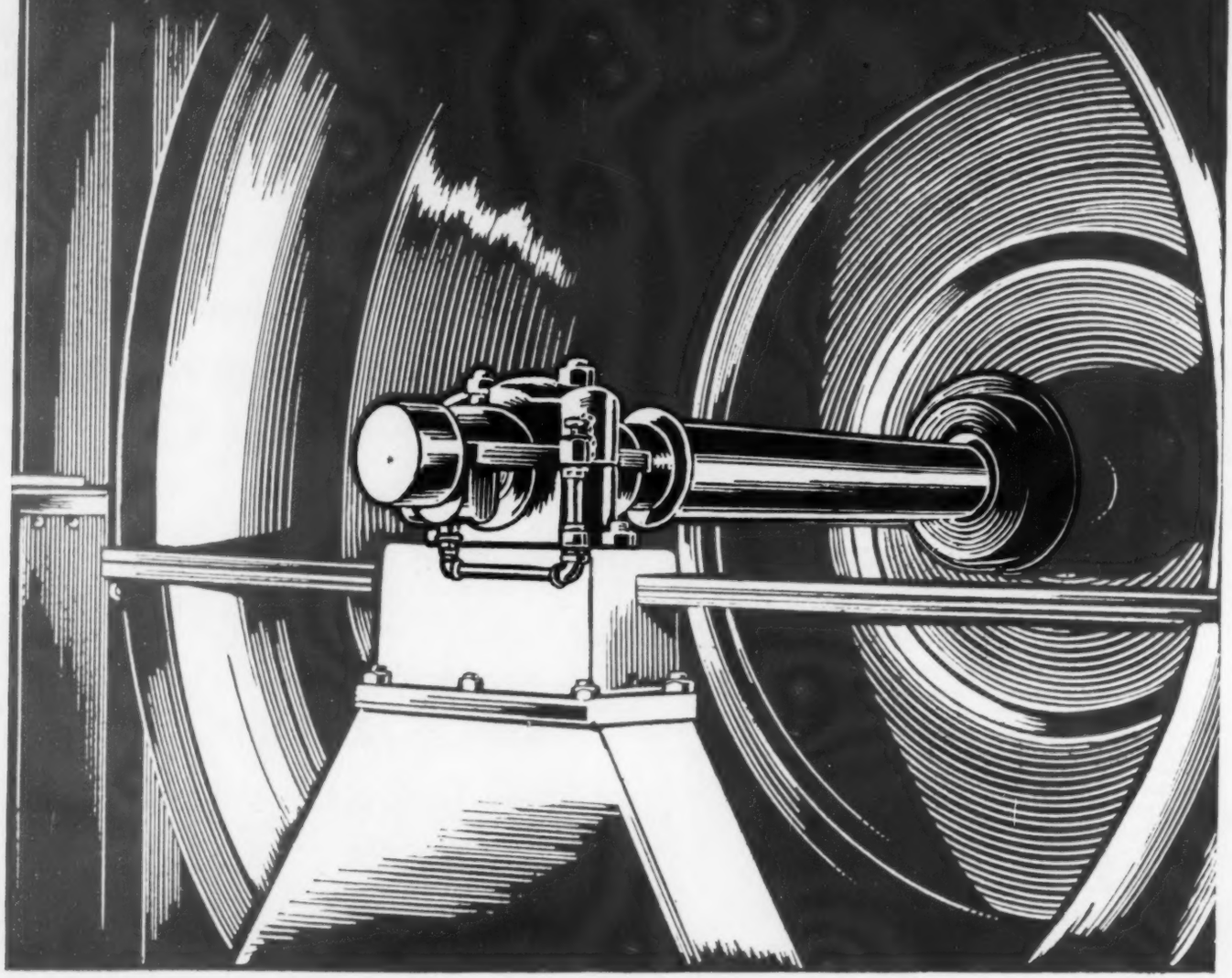
Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

"Buffalo"

AXIAL FLOW FANS

CENTRIFUGAL FANS

"BEARINGS RUN 10% COOLER



since changing to Tycol industrial greases

TYCOL
INDUSTRIAL LUBRICANTS

Boston • Charlotte, N. C.
Pittsburgh • Philadelphia

TIDE WATER ASSOCIATED OIL COMPANY
17 BATTERY PLACE · NEW YORK 4, N. Y.

"Production speeded 65%...
Repair costs slashed 30%...
Deposits eliminated...
Highly stable...
Consumption cut 25%..."

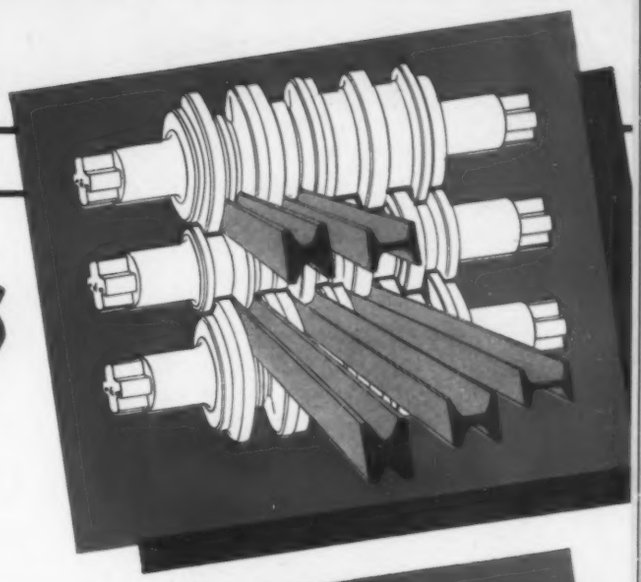
This report from a plant engineer typifies the kind of trouble-free, cost-cutting lubrication provided by Tycol Industrial greases. They contain more high-grade cylinder oil—less soap—which means better performance in every application.

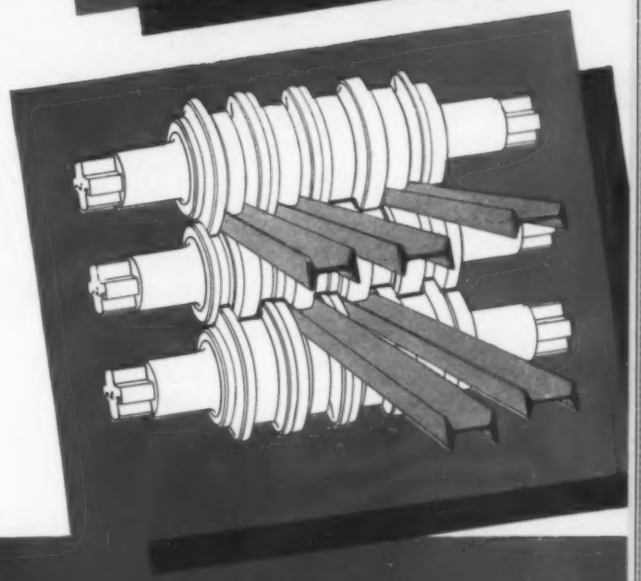
For aid in the selection of Tycol greases best suited for your particular needs, contact your nearest Tide Water Associated office today.

LUBRICATION—"ENGINEERED TO FIT THE JOB"

ROLLING TECHNIQUE ...

Standard Beams

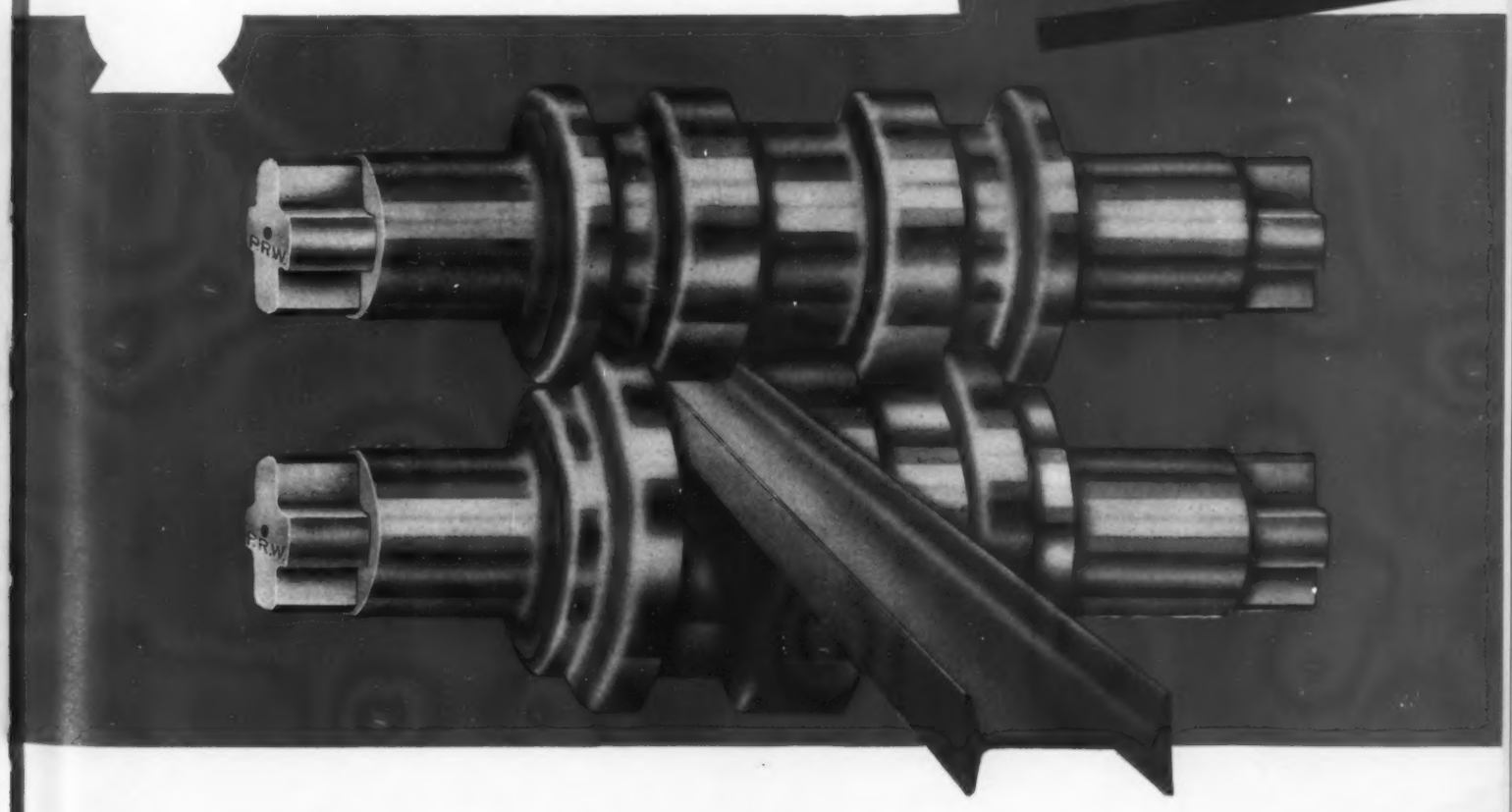




If it is the steel structure for a sky scraper, a warehouse, or a bridge, beams will furnish the main support. Whether it is a 3″ Beam or a 24″ Beam it will require deep passes cut into the rolls to form the flanges. Rolls with high tensile strength and resistance to side wear are required when rolling sections of this type.

Pittsburgh Rolls are made by skilled craftsmen whose thorough practical knowledge of metallurgy, foundry methods and accuracy in roll turning is the accumulated result of more than seventy-five years devoted to the exclusive manufacture of rolling mill rolls. The use of Pittsburgh Rolls can result only in *less cost per ton of steel rolled.*

PITTSBURGH ROLLS
Division of Blaw-Knox Company
PITTSBURGH, PA.



PITTSBURGH ROLLS

YALE FORK TRUCK

DEPENDABLE POWER

CUT MATERIALS HANDLING COSTS
MOVE MORE GOODS WITH SAFETY

•

You can do both . . . and *MORE* . . . when you use EXIDE-IRONCLAD POWERED Electric Trucks

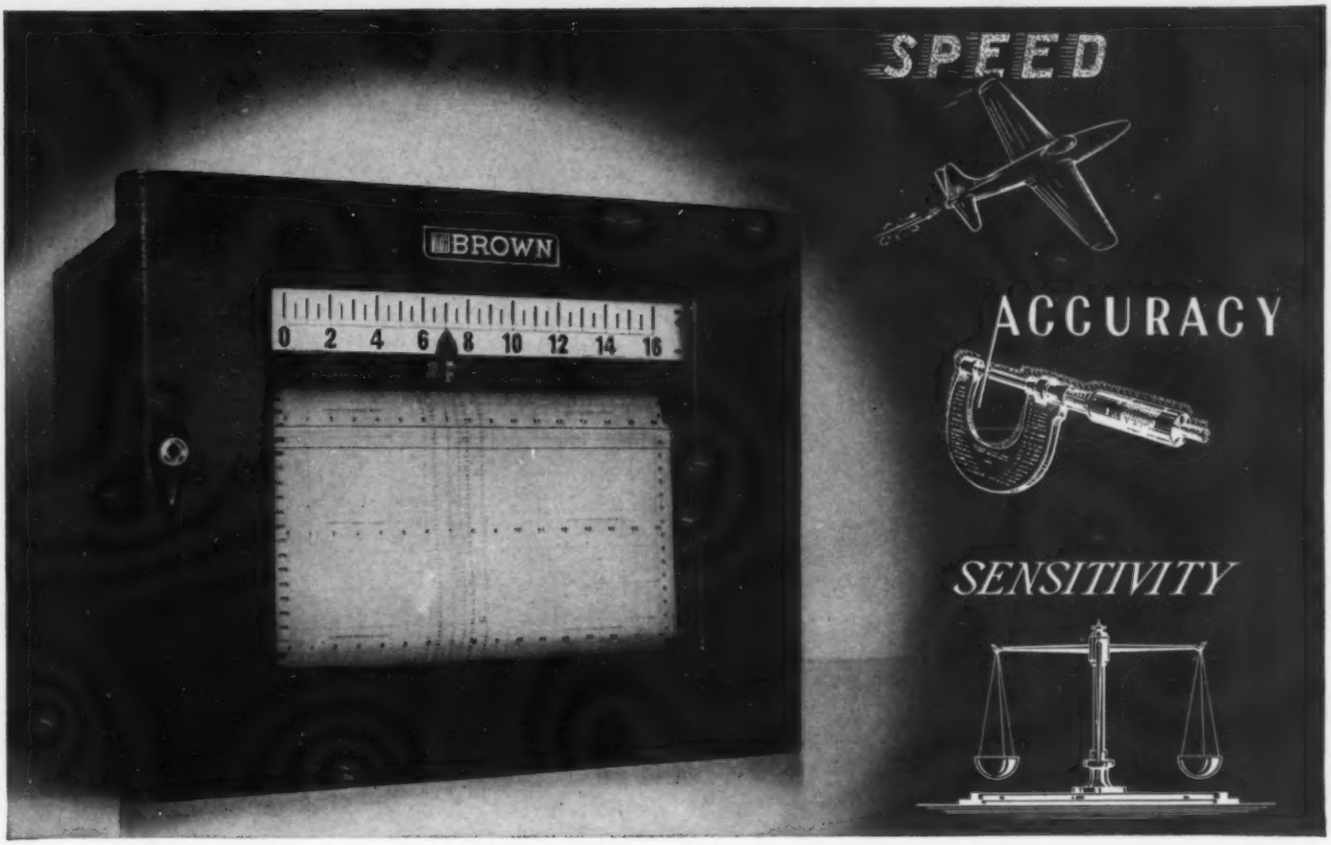
Wherever goods are lifted, hauled and stacked, efficient battery electric trucks and Exide-Ironclad power are effecting important economies all along the line. They do more work per man per hour and at less cost. They do it with greater ease and safety. And they maintain a steady pace straight through to the end of every shift.

Exide-Ironclad Batteries have the high power ability, the high maintained voltage and the high capacity that materials handling demands. You can always count on Exide-Ironclad Batteries for dependability, long-life and ease of maintenance.

Write us for a FREE copy of Exide-Ironclad Topics which contains "Case Studies" of materials handling problems. It tells how to cut handling costs up to 50% . . . covers latest developments in handling materials from receiving to shipping.

THE ELECTRIC STORAGE BATTERY COMPANY
Philadelphia 32
Exide Batteries of Canada, Limited, Toronto

YALE WORKSAVER



ElectroniK Potentiometers
Put THEORIES into PRACTICE

For six years, the Brown ElectroniK Potentiometer with its "Continuous Balance" system has provided new standards of dependability and performance in all Industries. Unparalleled accuracy, sensitivity and speed of response have enabled steel plants to *put theories into practice with laboratory accuracy.*

The Brown ElectroniK Strip Chart Recording Potentiometer — available for operation on 25 or 60 cycle current — will record 1 to 16 temperatures as measured by thermocouples, resistance thermometers or Radiamatic elements.

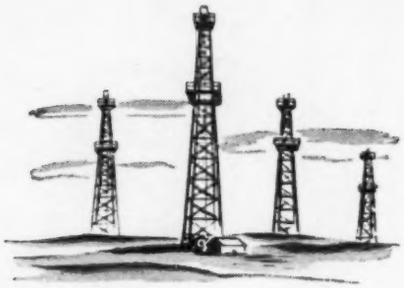
Auxiliary Mercury Switch Contacts are available for signalling, control or limit switch operation.

The "Continuous Balance" principle provides greatly improved control, reduced maintenance by a minimization of moving parts, ability to operate under conditions of severe vibration and high speed where necessary to record many variables.

Write today for Catalog 15-8. THE BROWN INSTRUMENT COMPANY, a division of Minneapolis-Honeywell Regulator Company, 4464 Wayne Avenue, Philadelphia 44, Pa. Offices in all principal cities.

TORONTO, CANADA
AMSTERDAM, HOLLAND BRUSSELS, BELGIUM LONDON, ENGLAND
STOCKHOLM, SWEDEN

BROWN *Electronik* POTENTIOMETERS



For unusual and large size bearings . . .

like the large, 48" OD angular contact ball bearing illustrated, or for other heavy duty, large size, or out-of-the-ordinary anti-friction bearing requirements,

Our specialized experience can help you.

Designing and building special anti-friction bearings such as ball-reciprocating, ladder type and radial roller bearings, as well as all major types of standard large size bearings, have long been a major activity of Torrington's Bantam Bearings Division. This background of experience is available to assist you in similar or entirely new problems involving the application of anti-friction engineering principles.

THE TORRINGTON COMPANY

SOUTH BEND 21, INDIANA — TORRINGTON, CONN.

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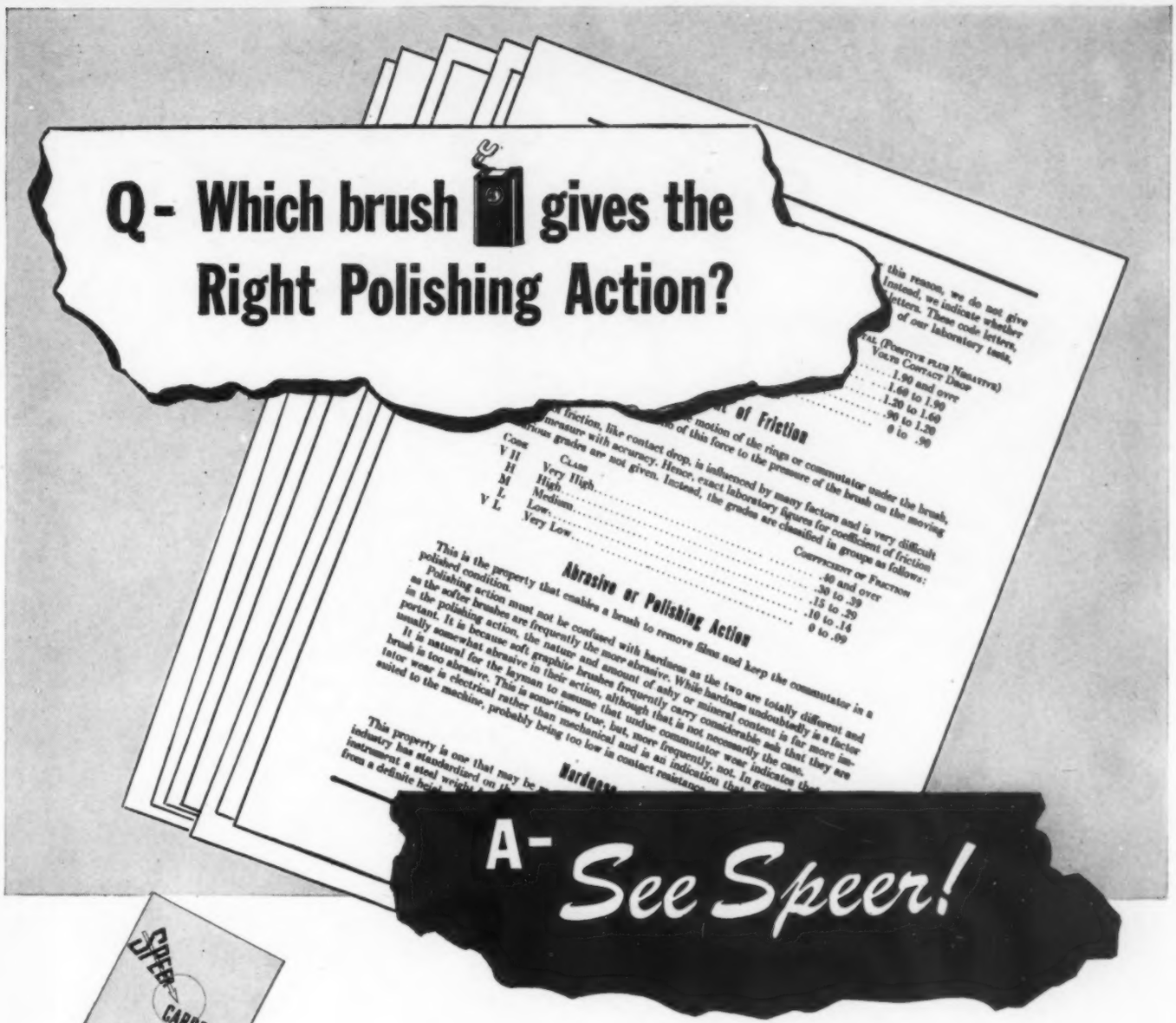
• NEEDLE • SPHERICAL ROLLER • STRAIGHT ROLLER • TAPERED ROLLER • BALL •



MORE ANSWERS in this book. Get it!

This catalog, *SPEER CARBON PRODUCTS*, gives detailed information on brush characteristics, includes Speer Brush Data Sheets. It answers your questions on brush selection, helps you find the right brush for your motors or generators!

A brush with the *right polishing action* keeps the commutator clean and without undue commutator wear. A brush with the *right polishing action* means top efficiency and long life for your commutating machines!

Selecting the brush with the right degree of polishing action for your particular requirements—selecting the *one* brush with the right combination of *all* the vital characteristics for your specific operating conditions is a specialty at SPEER! That's why Speer Brushes bring increased efficiency wherever they are installed!

Speer

CARBON COMPANY
ST. MARYS, PENNA.

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brushes • contacts • welding electrodes • graphite anodes • rheostat discs • packing rings • carbon parts

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Bleeding Ingots

bubbled out of existence

Today, "flushing" – bubbling a dry inert gas through metal just before casting – is the most efficient and economical method of eliminating "wild heats" or "bleeding ingots".

The test blocks shown on the left are typical examples. Both are 14% straight chrome stainless steel from the same heat. The test shown on the top, however, has a cheesy, porous structure – due to evolution of dissolved gas at the instant of freezing.

On the other hand, the bottom test block shows a perfectly dense structure – the result of flushing the molten metal prior to casting with an Airco inert gas – today's method for producing sound castings.

Airco Booklet ADR-35 gives you valuable information about this exceptional process which can be applied to both ferrous and non-ferrous metals. Fill in and mail the coupon for your copy. Air Reduction, 60 East 42nd Street, New York 17, N. Y. In Texas: Magnolia Airco Gas Products Company, Houston 1, Texas. Represented Internationally by Airco Export Corporation.

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HUNT Quick-As-Wink Valves give precision control on 105 ton punch press

The Hunt single solenoid, spring return valve insures positive clutch and brake control on all Verson presses.

This 105-ton punch press is made by the Verson Allsteel Press Company of Chicago.

Here's another nationally known manufacturer who relies on Hunt Quick-As-Wink valves. On this Verson Allsteel punch press, a 3-way, single solenoid, spring return valve gives accurate and positive control of the operating clutch and brake. In addition, the manufacturer states, "We use Quick-As-Wink solenoid valves on all of our mechanical presses and special equipment." . . . C. B. Hunt & Son, Inc., manufactures single and double solenoid valves—hand, foot, and diaphragm operated valves for air—hand and pilot operated hydraulic types for water or oil applications. Write today for further information and for your free copy of the new Hunt Bulletin 107A.

THE HIGHER THE PRESSURE — AIR WATER OIL — THE TIGHTER THE SEAL

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SALEM • OHIO

SUBMERGED FOR 13 YEARS AND STILL GOOD!

...isn't this the kind of splice you'd like to make?

This photograph shows one of several splices protected with Okonite and Manson Tapes after removal from test following 13 years immersion in water.

The story of this long-time test explains the confidence placed by electrical men in Okonite and Manson Tapes especially for splicing and tapping underground cables installed in wet locations — such as non-leaded rubber-insulated network cables and power feeders.

Each year all of these splices, made on 4/0 Okosheath 600-volt network cable, withstood a test at 7000 volts a-c for five minutes. Insulation resistance readings were still in excess of 370,000 megohms when the splices were removed for examination. Such prolonged immersion had not affected the electrical strength.

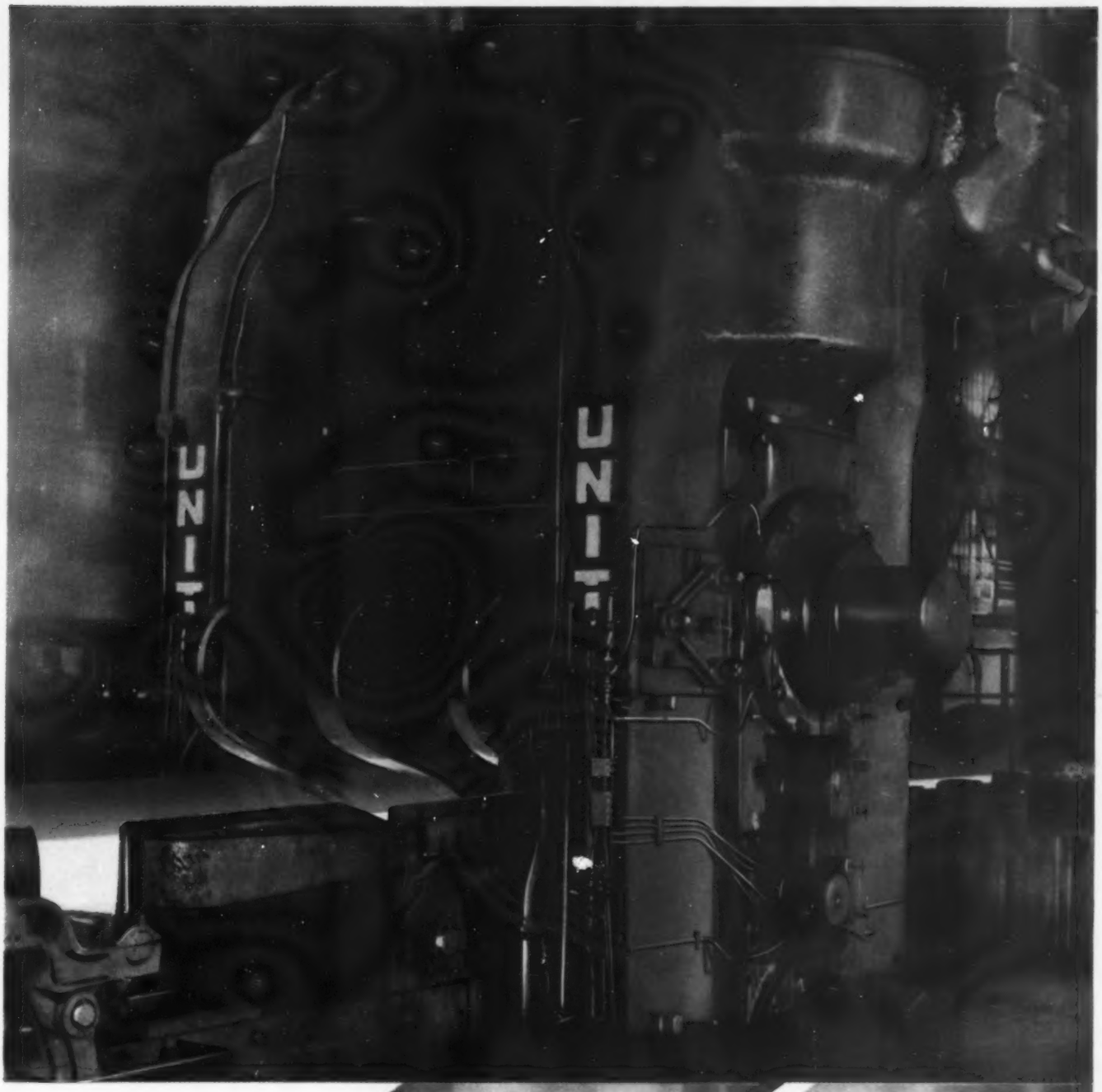
Dissection showed that the Okonite splicing compound was securely bonded to the connector and conductors and had become vulcanized into a firm, homogeneous seal that not one drop of water had penetrated. That's why so many experienced users say that for long, trouble-free service there's nothing like Okonite Rubber and Manson Friction Tape for splicing rubber-insulated cables.

We'd like to show you how easy it is to make joints like these. Just drop us a note on your company letterhead and ask for Bulletin OK-1007 *and samples* of these high-grade splicing tapes. The Okonite Company, Passaic, N. J.

SPECIFY

OKONITE SINCE 1878 **and MANSON TAPES**

5037



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HOT STRIP MILL

UNITED ENGINEERING AND FOUNDRY COMPANY

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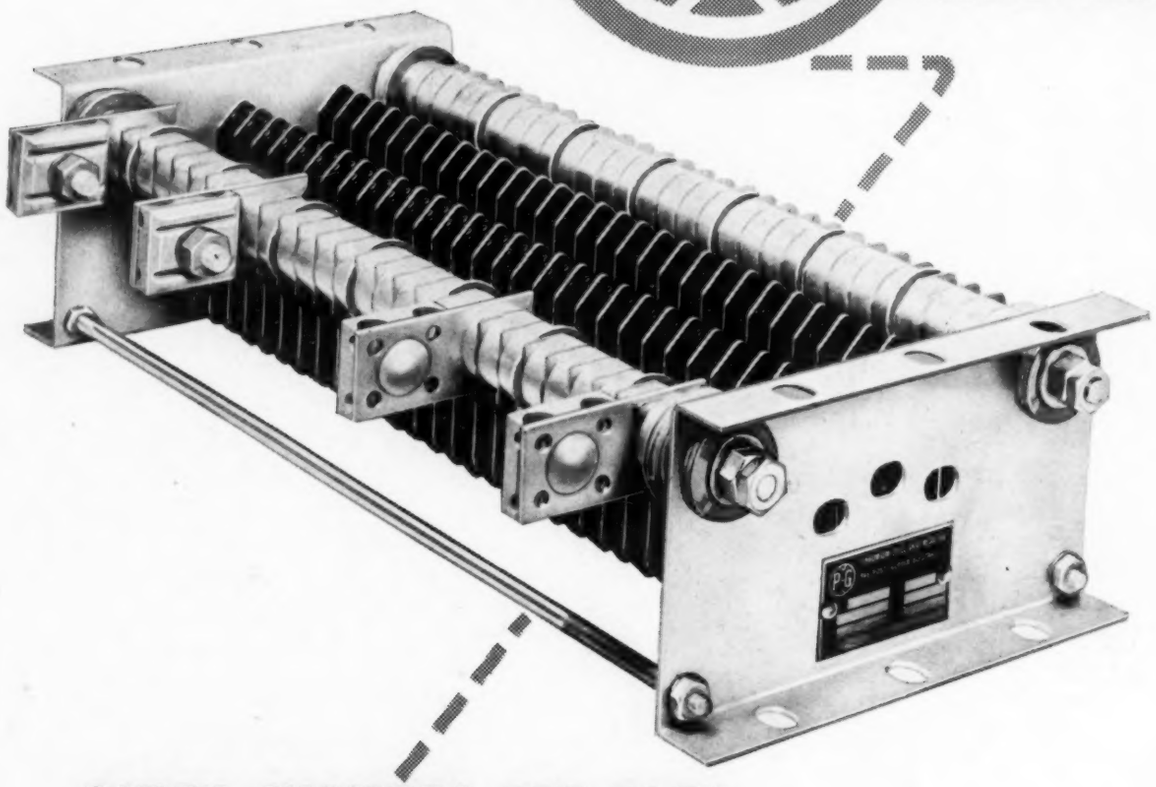
INDIVIDUAL RESISTOR REQUIREMENTS *Solved...*

with *Nonbreakable* P-G STEEL GRID RESISTORS!



QUICK CHANGES ARE EASY...

Little effort required to make adjustments.

- Minor variations often possible by wire change to other available terminals.
- Greater variations easily produced by movement of terminal position in the unit.
- Major variations effected by removal or addition of one or more standard banks.

For minimum maintenance and maximum production, specify P-G.

P-G

The Nonbreakable Steel Grid Resistor

THE POST-GLOVER ELECTRIC COMPANY

• ESTABLISHED 1892 •

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Soon Pays for Itself with Savings

With a labor-saving Philco Battery-powered hand truck, one man—one load—one trip is all it takes to move tons of materials in a hurry. There's big capacity both in the truck and in its Philco Battery—extra work energy to lift, haul and spot more loads per shift. Write for specification data on extra capacity Philco Batteries—types XL, XVL and the long-life Philco "Thirty".

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STORAGE BATTERIES

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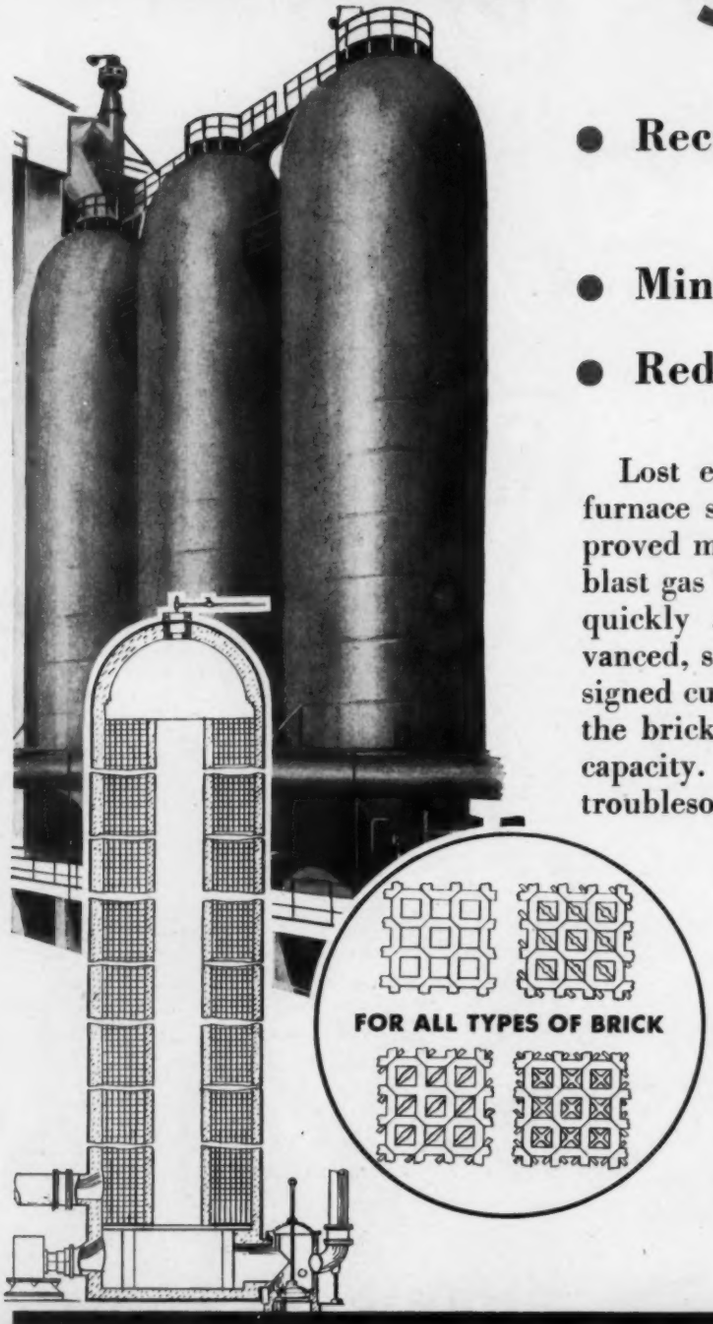
NEW CHECKER CLEANING SERVICE



- **Reconditions Stove Flues Economically.**
- **Minimizes Brick Replacement.**
- **Reduces Shutdown Time.**

Lost efficiency can now be restored to blast furnace stoves by Pittsburgh Pipe Cleaner's improved method of checker cleaning. Dust and hot blast gas deposits are removed from flue surfaces quickly and economically by Pittsburgh's advanced, scientific cleaning methods. Specially designed cutter tools remove all deposits and restore the brick to 90-95% of original heat absorption capacity. Brick damage resulting from costly, troublesome lancing can be eliminated, and stoves are put back to work with renewed efficiency.

Avoid costly shutdowns of long duration resulting from corroded checkers and brick replacement by asking our nearest branch in your district for an estimate. Ours is an integrated engineering and operating organization that is helping blast furnaces and steel plants to stretch maintenance dollars every day.

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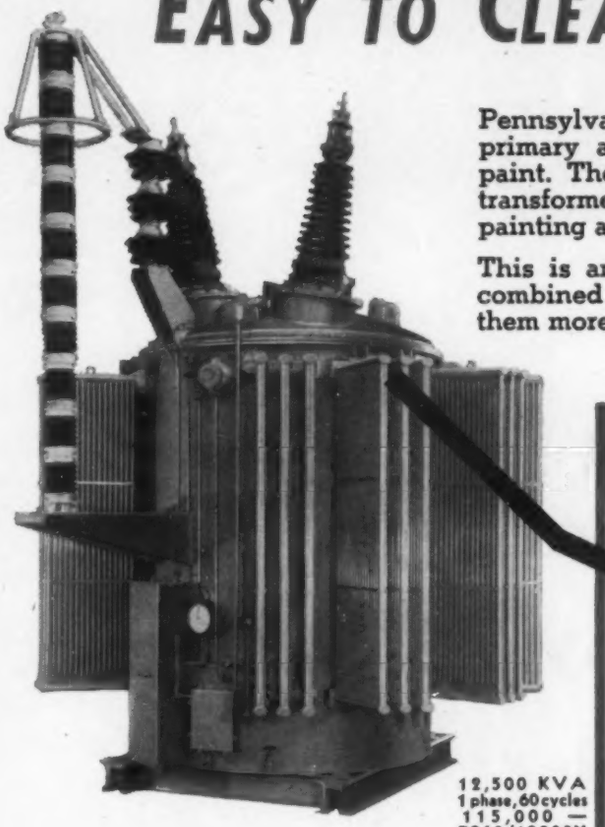
In the Factory or in the Field

PENNSYLVANIA UNI-ROW RADIATORS ARE

EASY TO CLEAN..EASY TO PAINT

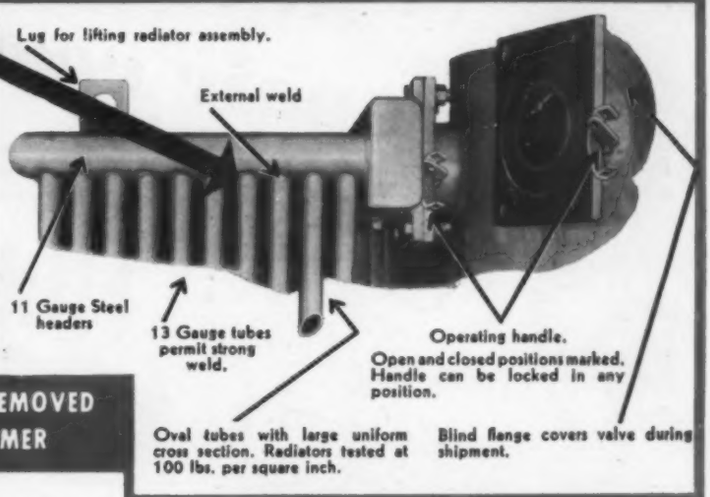


12,500 KVA
1 phase, 60 cycles
115,000 —
7960/13800Y
volts

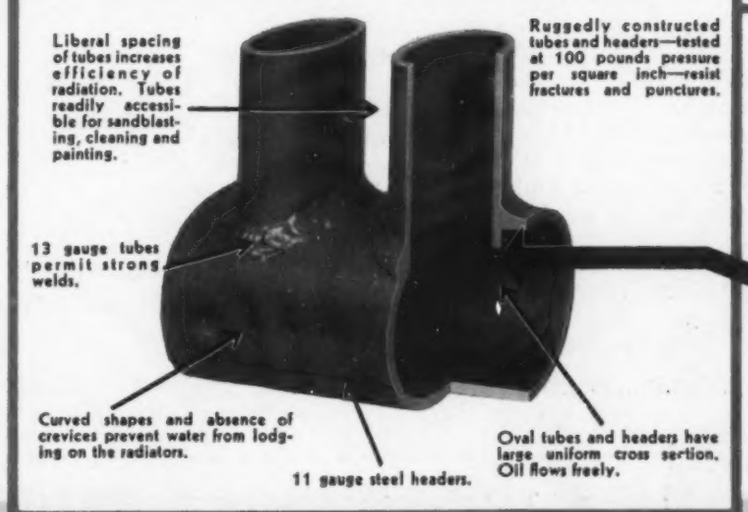
Pennsylvania Uni-Row radiators are painted with one primary and two finishing coats of special transformer paint. The generous spacing of the radiators around the transformer facilitates cooling and makes cleaning and painting a very simple matter.

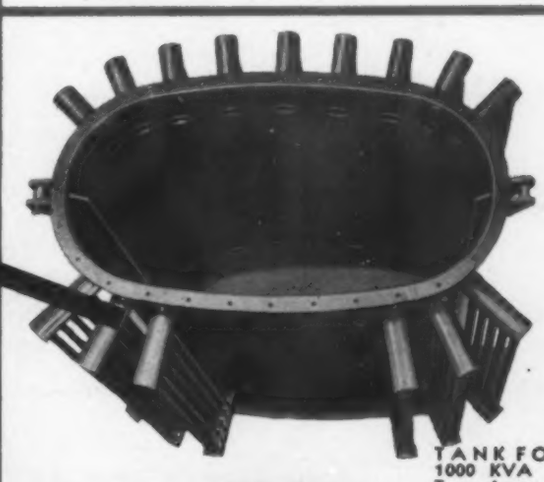
This is another instance where function and design are combined in Pennsylvania Power Transformers to make them more efficient and easier to maintain.

PERMANENTLY WELDED UNI-ROW RADIATORS RUGGEDLY CONSTRUCTED OF HEAVY GAUGE STEEL


Lug for lifting radiator assembly.
External weld
11 Gauge Steel headers
13 Gauge tubes permit strong weld.
Operating handle.
Open and closed positions marked. Handle can be locked in any position.
Oval tubes with large uniform cross section. Radiators tested at 100 lbs. per square inch.
Blind flange covers valve during shipment.

DETACHABLE UNI-ROW RADIATORS CAN BE REMOVED WITHOUT DRAINING OIL FROM TRANSFORMER


Liberal spacing of tubes increases efficiency of radiation. Tubes readily accessible for sandblasting, cleaning and painting.
Ruggedly constructed tubes and headers—tested at 100 pounds pressure per square inch—resist fractures and punctures.
13 gauge tubes permit strong welds.
Curved shapes and absence of crevices prevent water from lodging on the radiators.
11 gauge steel headers.
Oval tubes and headers have large uniform cross section. Oil flows freely.



TANK FOR
1000 KVA
Transformer

Pennsylvania TRANSFORMERS

Pennsylvania TRANSFORMER CO.

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Read what they say
about NON-FLUID OIL
TRADE MARK REGISTERED
"We have cut our repair costs 75% since changing over to NON-FLUID OIL"
TRADE MARK REGISTERED

Unsolicited testimonials such as this are NON-FLUID OIL's best advertisements. They prove beyond question that the "built-in" adhesiveness and stability of NON-FLUID OIL is paying big dividends for users in all branches of industry.

There's a specific grade of NON-FLUID OIL for every type of lubrication. Although possessing unique and exclusive lubricating properties NON-FLUID OIL is applied in the same manner as greases and liquid oils and does not require the purchase of any special lubricating appliances or any changes in lubricating technique.

Clip and mail the coupon today for your generous sample of NON-FLUID OIL. We invite you to try NON-FLUID OIL at our expense to see how it will cut down yours.

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N. Y. & N. J. LUBRICANT CO., Dept. IS
292 Madison Avenue, New York 17, N. Y.
Please send me testing sample of NON-FLUID OIL to be used in the following machinery:

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Company.....

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The reason? Year after year Morgan has devised better mill layouts, better mechanical equipment that has met the price and quality demands of your customers.

If you are planning a new mill let us put before you our latest ideas in plant layout and equipment — ideas designed to *pay-off* . . . in production . . . in precision . . . in profit.

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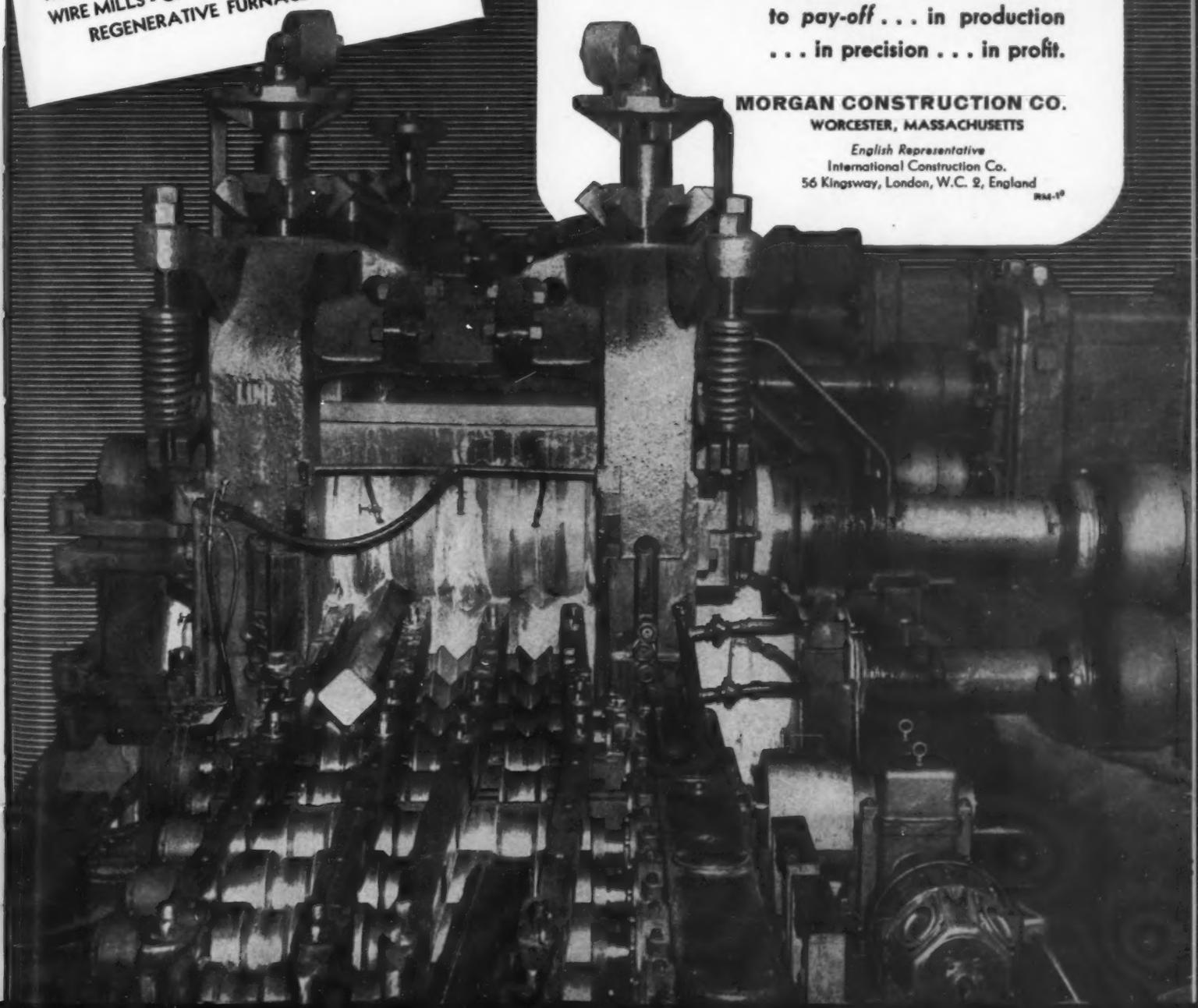
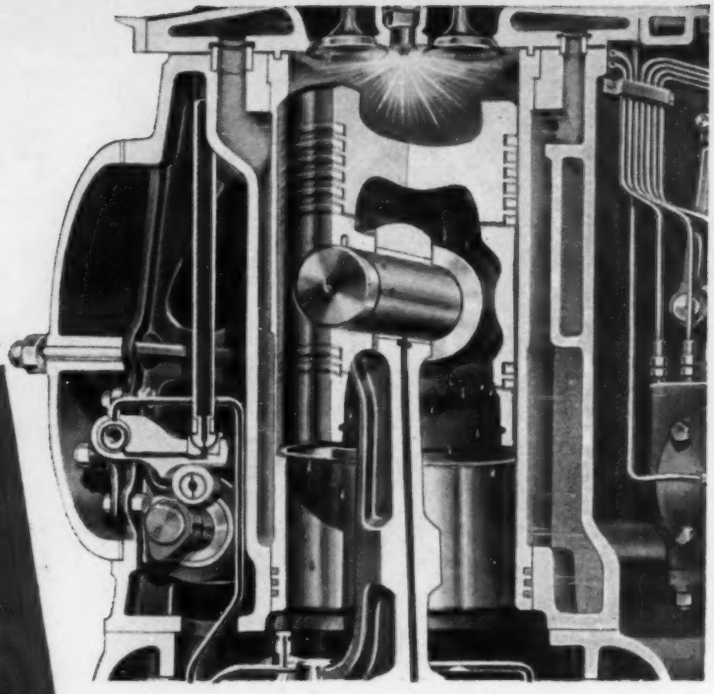
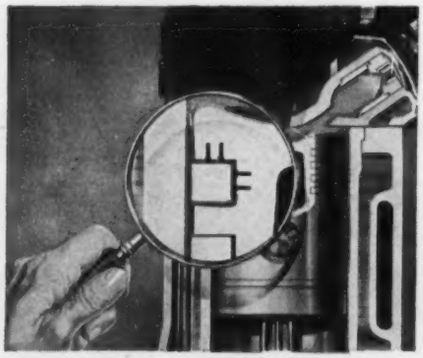
ROLLING MILLS - MORGOIL BEARINGS
WIRE MILLS - GAS PRODUCERS - AIR EJECTORS
REGENERATIVE FURNACE CONTROL





YOUR Socony-Vacuum Representative is a Sales Engineer, trained through years of experience in the lubrication of industrial plants of all kinds. He thinks in terms of the inside of your machines. He knows bearings, cylinders and gears . . . the operating difficulties that must be met and overcome. Called into your plant to help you obtain maximum machine efficiency, he works with your own engineers, a friendly expert adviser . . . on your staff but not on your payroll.

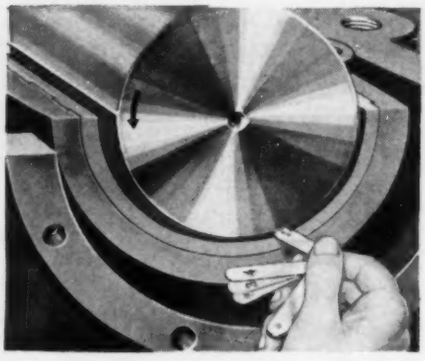


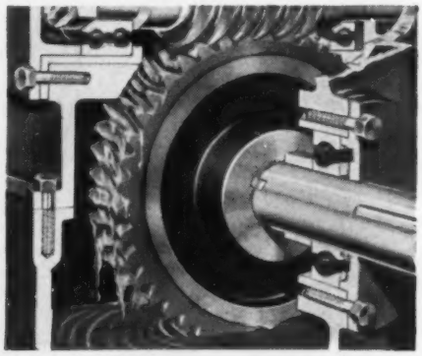
Studies Operating Problems

Every unit in your plant has its own operating characteristics. For instance, the loads on certain gears, the temperatures of bearings. Your Socony-Vacuum Engineer studies all factors.

Recommends Correct Lubricants

With all the facts about your machines, your Socony-Vacuum Engineer is able to recommend the right Gargoyle oil or grease and the best application technique for every problem.





Sets up a Lubrication Program

Your Socony-Vacuum Engineer provides complete lubrication schedules. He helps with storage problems and lubrication training. Finally, he prepares progress reports on the benefits obtained.

The Inside Track to Profits . . .

Socony-Vacuum Correct Lubrication

SOCONY-VACUUM

GARGOYLE Lubricants

SOCONY-VACUUM OIL CO., INC., and Affiliates: Magnolia Petroleum Co., General Petroleum Corp. • Tune in The Mobilgas Program, Monday Evenings, 9:30 E.D.T.—NBC

490,000 HOURS
OF BILLETEER OPERATION
with ONLY 1
DISABLING ACCIDENT

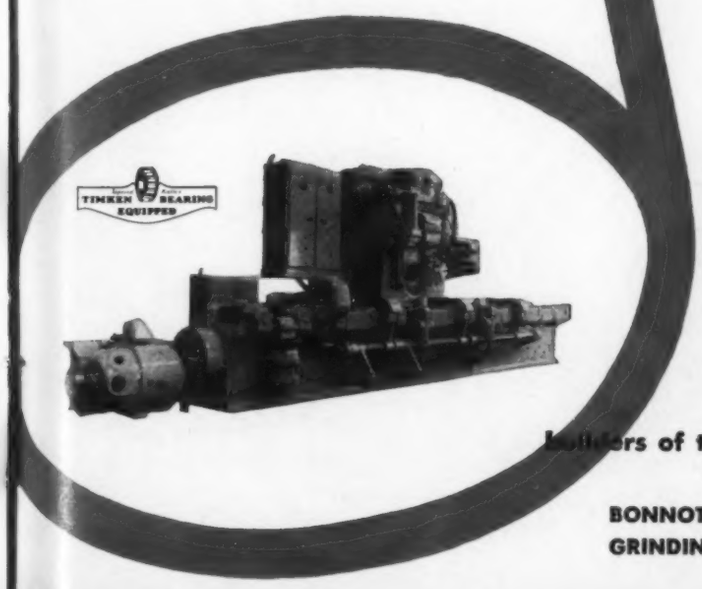
....a high note in Billeteer safety

Yes, the Billeteer can bring a new high in safety to your billetshed operations. In one leading midwestern mill, records show that during 490,000 man hours (or 31 machine years) of Billeteer use, there has been only 1 disabling injury to operators and helpers.

Compared to manual methods of billet conditioning, this safety record seems phenomenal. Actually, the reasons are simple. For the Billeteer is *built* to take the punishment of billet chipping. Its rugged, 45 ton weight spares the operator from the jitters, grogginess, and accident-causing fatigue. Simple, centrally-located controls keep operator at peak efficiency.

....note the additional Billeteer advantages

- Cuts labor costs.
- Speeds chipping.
- Chips 100% recoverable.
- Always on the job.
- Boosts worker efficiency.
- Reduces billet inventory.
- Speeds critical deliveries.



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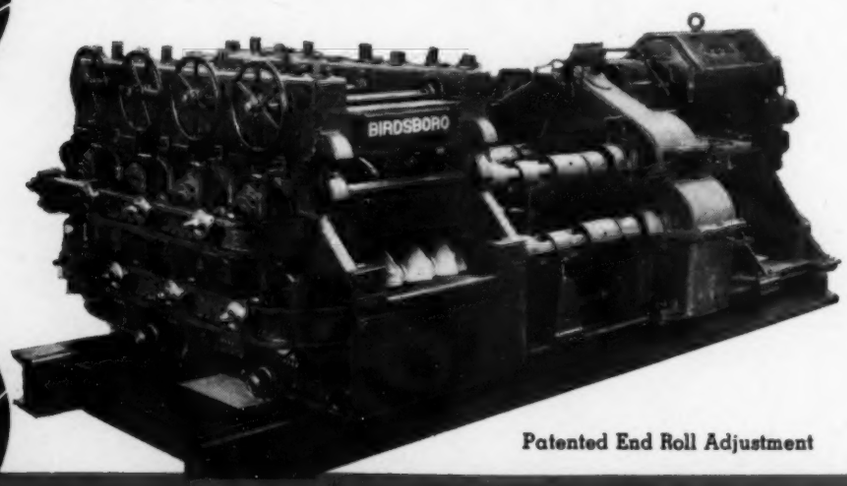
Engineered
FOR LOWER OPERATING COSTS
BONNOT

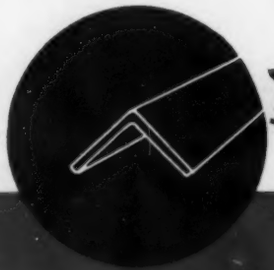
Builders of the BILLETEER • THE BONNOT COMPANY • CANTON 2, OHIO

BONNOT BILLET INSPECTION TABLES • CHARGING TABLES • COLD SAWS
GRINDING PANS • CLAY MIXERS • CLAY FEEDERS, ETC.

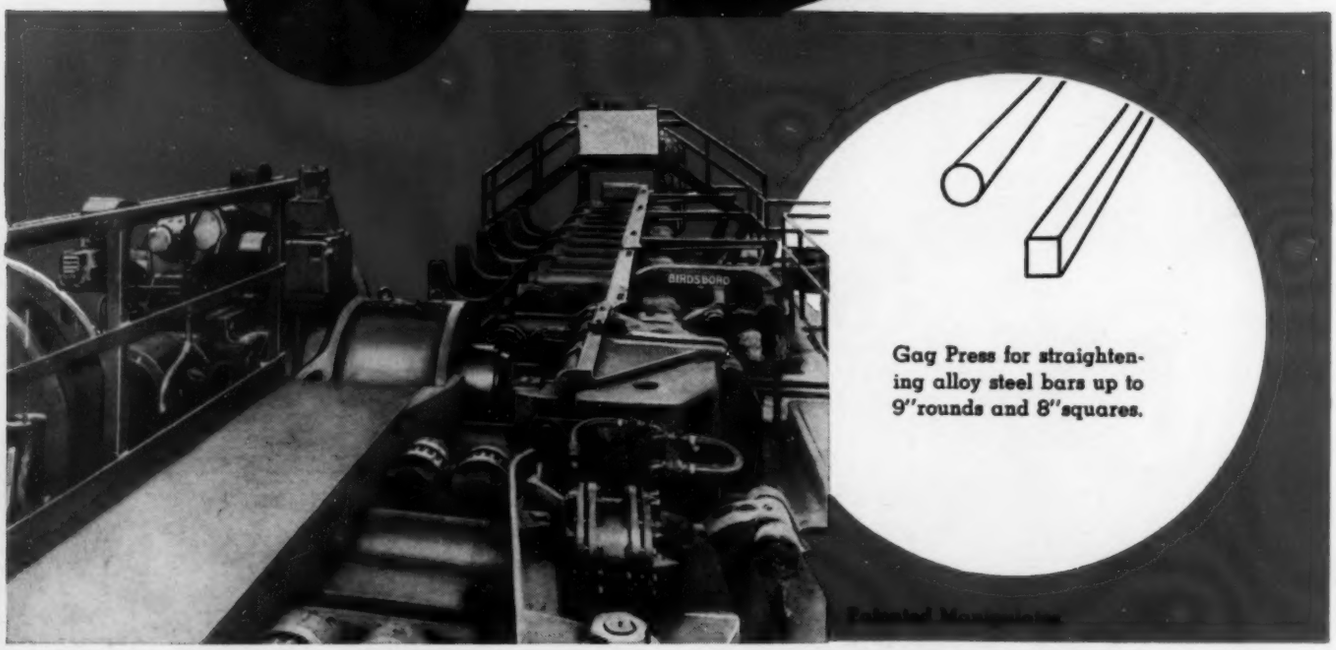
Rail Straightening Press having capacity for straightening 150 lb. rails.



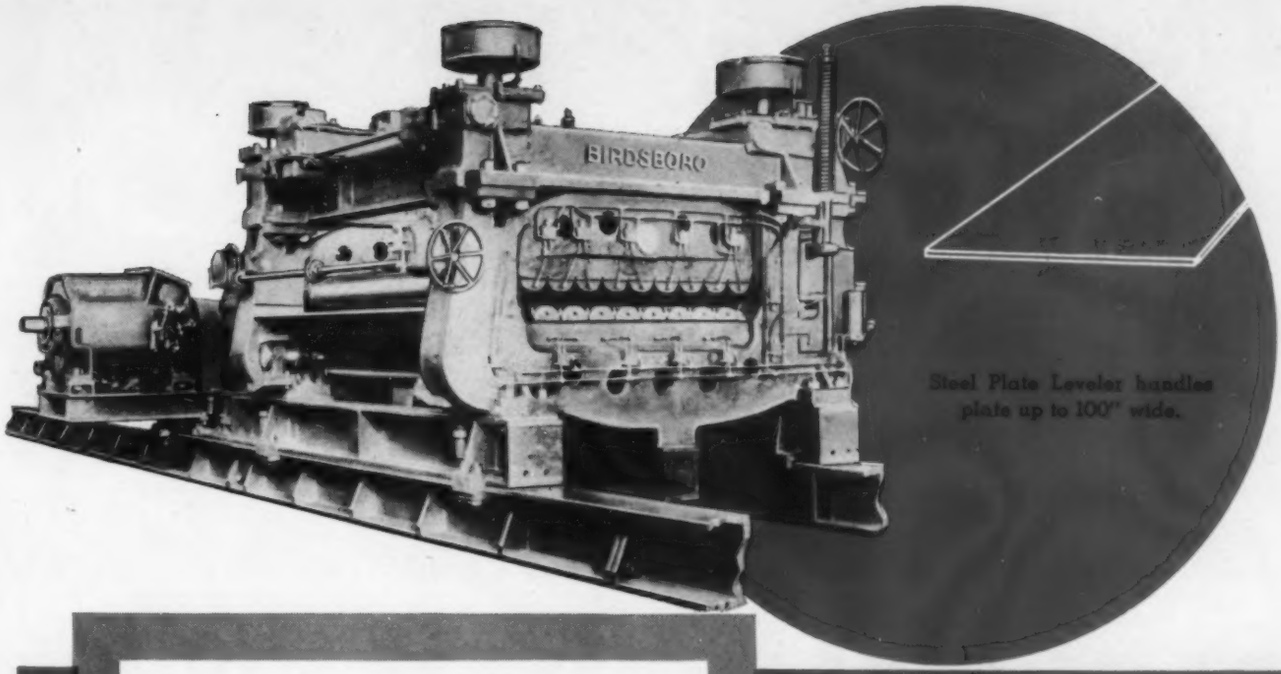
Structural Shape Straightening Machine with capacity up to 6" x 6" angles.

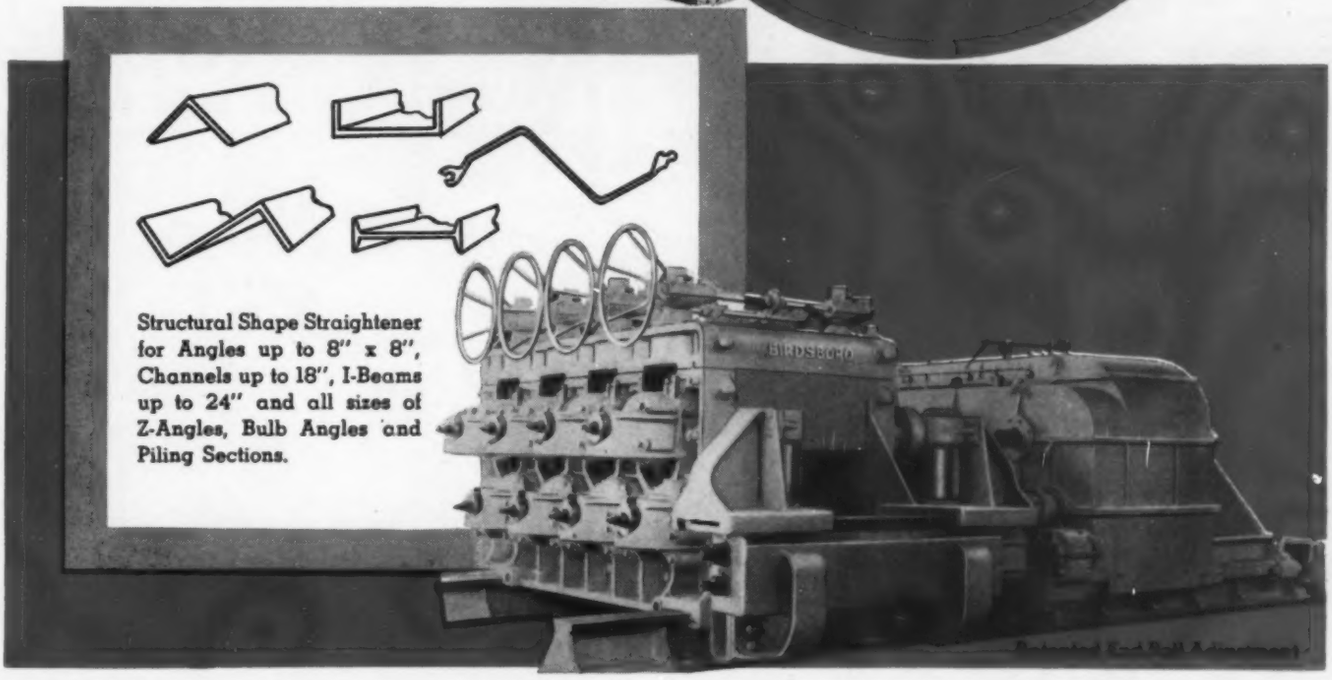


Patented End Roll Adjustment



Gag Press for straightening alloy steel bars up to 9"rounds and 8"squares.



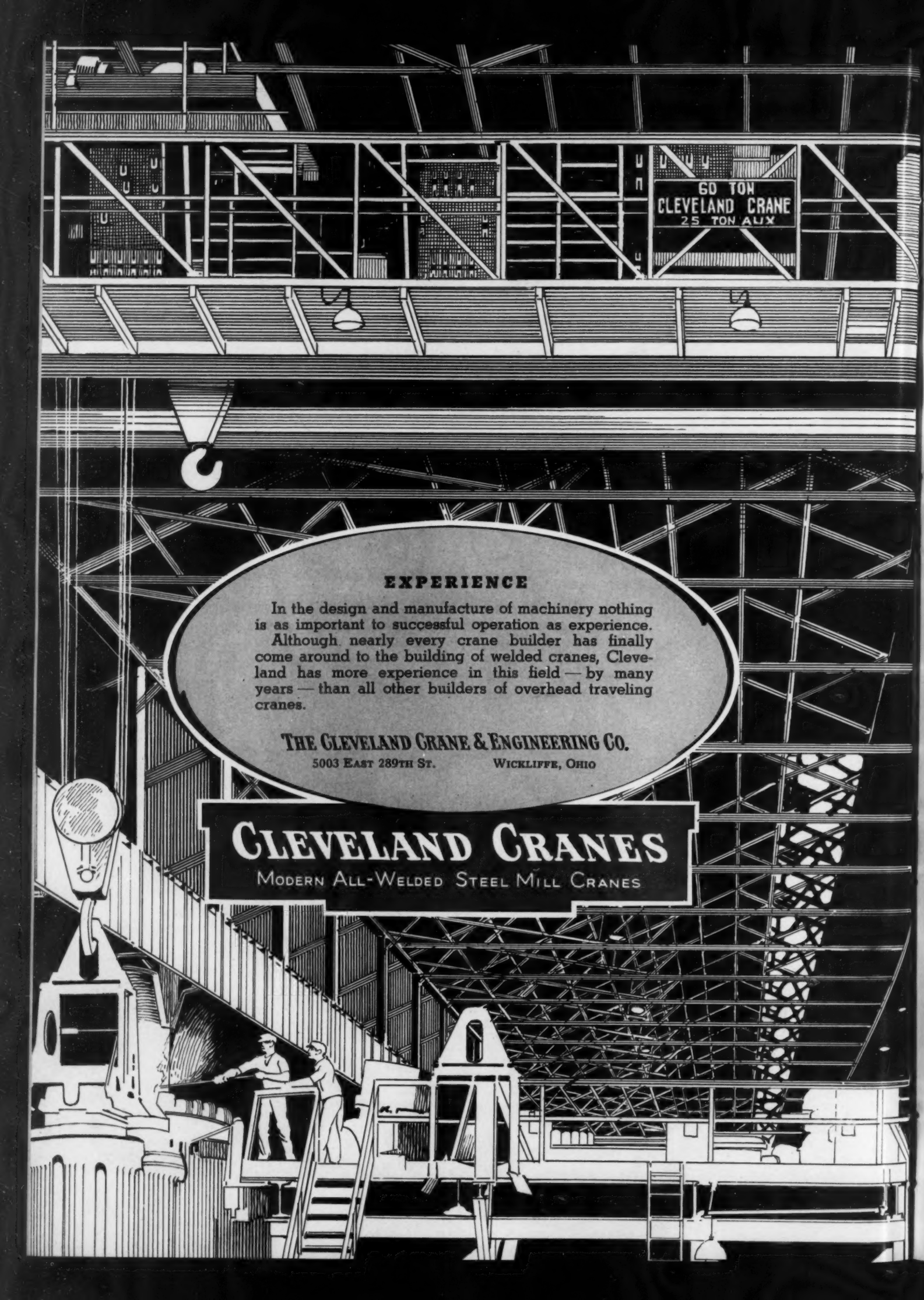

Structural Shape Straightener for Angles up to 8" x 8", Channels up to 18", I-Beams up to 24" and all sizes of Z-Angles, Bulb Angles and Piling Sections.
BIRDSBORO

These five versatile Birdsboro Machines meet the major straightening needs of heavy industry. They have been designed for easy, trouble-free operation and built for rugged service . . . with recently developed features that reduce production costs.

When your problem involves the straightening of any metal shapes in large or small sizes, investigate Birdsboro's facilities for producing machinery to meet your specific requirements. Our designers and engineers will welcome the opportunity to work with you to arrive at a practical solution to your problem. Get in touch with us today.

BIRDSBORO STEEL FOUNDRY & MACHINE COMPANY • BIRDSBORO, PENNSYLVANIA
Manufacturers of Steel Mill Equipment, Iron and Steel Rolls, Hydraulic Presses, Crushing Machinery, and Special Machinery

BIRDSBORO
STEEL MILL EQUIPMENT



EXPERIENCE

In the design and manufacture of machinery nothing is as important to successful operation as experience.

Although nearly every crane builder has finally come around to the building of welded cranes, Cleveland has more experience in this field — by many years — than all other builders of overhead traveling cranes.

THE CLEVELAND CRANE & ENGINEERING CO.

5003 EAST 289TH ST. WICKLIFFE, OHIO

CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

Crops *and* Shorts

INGOT production for the first quarter of 1947 totaled 20,919,055 net tons (93 per cent capacity), almost doubling the first quarter of 1946. This total was made up of 18,998,051 tons of open hearth steel, 1,077,589 tons of bessemer steel and 843,415 tons from electrics. Operating rates in the three types were respectively 95.1, 84.8 and 67.4 per cent of capacity.

March production totaled 7,284,516 tons, breaking the peacetime record established in January.

▲

A lawsuit which should be of interest to the steel industry is that entered by a customer against a producer, seeking to recover costs of labor put on steel of allegedly unsatisfactory quality.

▲

IN the first two months of 1947, the steel industry shipped a total of 9,689,414 net tons of steel of all types. Of these products, 2,818,942 tons were hot and cold sheet and strip. If these proportions carry through the entire year, 1947 will see more than 17,000,000 tons of sheet and strip shipped, breaking the record of 16,165,000 tons set in 1941.

▲

STATISTICS can be dangerous things. A statistician once went duck hunting. When a duck flew overhead he fired one barrel of his shotgun. The shot went three feet back of the duck. He shifted his aim and fired again. The shot went three feet ahead of the duck. Based on the law of averages, the statistician had shot the duck.

▲

HUNTERS such as the statistician can't be blamed for the fact recently announced by the Department of Interior that American waterfowl have decreased for the past three years. The Fish and Wildlife Service estimates our present population of ducks and geese at 54,000,000 — scarcely one for each pot.

▲

IF there are not enough ducks and geese to go 'round, we can at least go fishing. The United States now turns out almost 70,000 fish hooks every hour. Prior to 1940, these items were principally imported from Europe.

OF the tin and terne plate produced during January and February, about 38 per cent was coated by the electrolytic process.

▲

THE overall price of finished steel is now estimated to average $57.27 per ton, while costs are estimated at about $48.60 per ton. Hence, a margin of about $8.67 per ton is indicated between price and cost. The wage hike recently granted will bring this margin down to between $5.50 and $6.00 per ton.

▲

WE have noticed that suggestion systems are again receiving considerable attention, even to the point of being the subject of a national conference. Wonder if they have found a method of keeping out gum wrappers and suggestions that the boss be fired.

▲

THE transportation bill for the steel industry in 1944 totaled $872,515,000, according to the American Iron and Steel Institute. This averages approximately $9.73 per ton of ingots produced. Inbound freight charges were $508,397,000 while outgoing shipments accounted for $364,118,000.

In 1945 the total transportation cost was $773,408,000, averaging $9.70 per ton of ingots.

▲

WINNER of the McKune award of the AIME Open Hearth Committee this year was E. B. Hughes of Wheeling Steel Corporation. On the dinner program Mr. Hughes' company connection was inadvertently listed as Weirton Steel Company. It would be nice if Mr. Weir put through a raise for Mr. Hughes.

▲

SCRAP prices and shortages have led to the use of more iron ore in the open hearth. It has been estimated that up to 13 per cent of the weight of purchased scrap is being replaced by iron from lump ore. This practice results in an increase of about 4 per cent in melting time. The recent break in scrap prices may reverse this trend.

▲

EVERY year, about this time, we see throngs of hopefuls clustered around racks of garden seed packets, each packet illuminated with colorful products to suit the dreams of the wildest optimist. These things, plus a whiff of spring in the air, seem to obliterate all memories of the aching backs, bruised hands and blasted hopes of previous years.

▲

INDICATIVE of the extent to which we are dependent on the automotive industry, of 1,773,507 patents granted by the United States patent office since 1900, almost one-fifth relate to the auto industry.

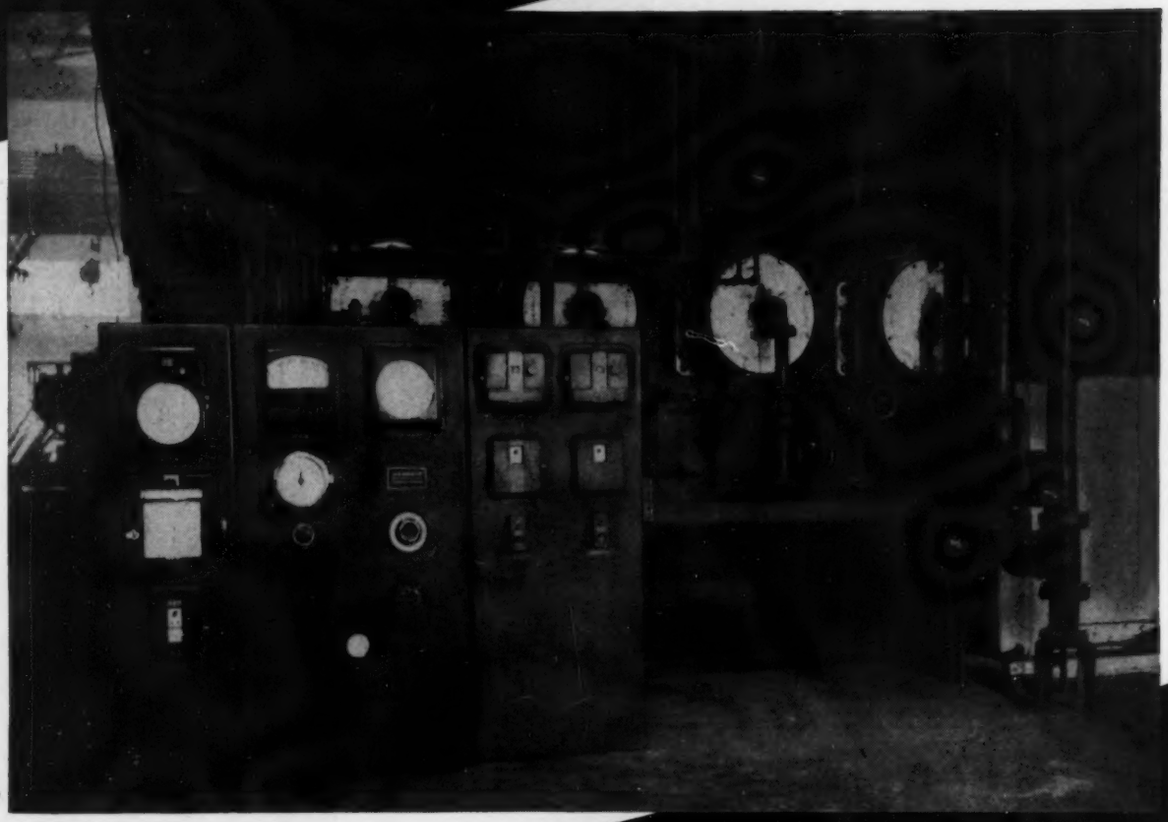
▲

WORRY has been well defined as a circle of inefficient thoughts whirling about a pivot of fear.

▲

A new steel plant is to be built in India, either in Bihar or western Bengal. It will have an initial capacity of 500,000 tons per year, with 1,000,000 tons ultimately planned.

IN AND OUT SLAB HEATING FURNACE



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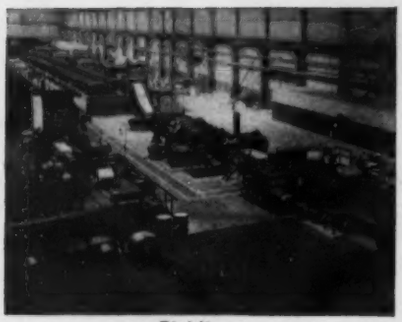
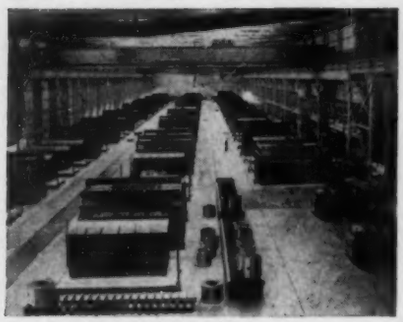


Pickling



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Iron AND Steel ENGINEER

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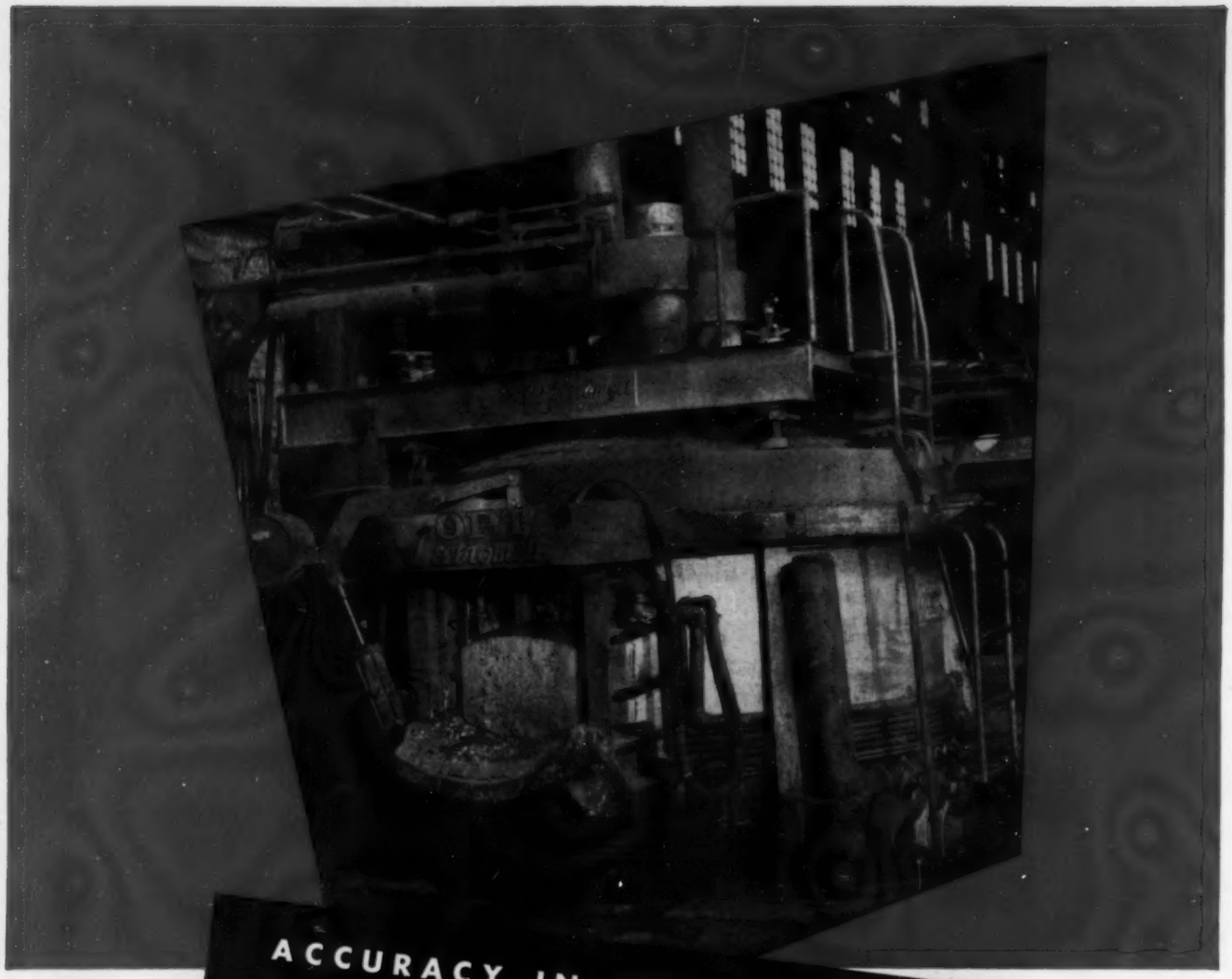

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THE SCHEDULING OF MAINTENANCE SHOPS

. . . . given proper respect and support, the shop schedule can be a very important and helpful phase of shop operation . . . .

BY L. E. FULLER

Superintendent, Maintenance Department

Carnegie-Illinois Steel Corporation

South Works, Chicago, Illinois

▲ THE scheduling of maintenance shops, to be successful, depends entirely on one principle — complete co-operation of management, customer, shop, and planning.

This principle is so important that its disregard will cause failure in schedules, regardless of the perfection of the system, its application, or the ability of the personnel. This factor is what we like to call the "planning square". Visualize, if you will, a four-sided frame, hinged on each corner, surrounding an entity called "scheduling". One side of the frame is the "shop", the next side is the "planning department", the third side is the "customer", and the last side is "management". So long as the hinges connecting each side remain intact with the pin of "co-operation", the schedule can be controlled and directed by the combined forces of management, customer, shop, and planning. However, remove the pin, remove co-operation between any two sides and there is a break that results in an uncontrolled schedule, or in no schedule.

Let us consider briefly the "management" side of planning. Scheduling, specifically, and planning, in general, as handled by a planning organization, must have the complete approval and support of management. It must have approval and support that springs from the conviction of belief and the desire to assist; that is maintained by a working knowledge of the principles and problems of scheduling; that is activated by a sincere desire to make the program an operating success.

Quite naturally, the attitude of management toward planning and scheduling is reflected down through the shops. However, when shop supervision and personnel are working more closely with the planning organization, they become the very breath of the schedule. They must be willing to be relieved of non-operating responsibilities, of the necessity of preliminary planning, of order follow-up and order progress, and of the clerical work that is imperative to the collection and transmission of order information. It seems incomprehensible that any busy supervisor would not be more than willing to delegate such work to personnel who are trained to perform just that service. But in many cases, that is not the situation. Often, the supervisor is willing to leave this work to planning personnel, but wants them also to accept all of the responsibility. In other cases, he will fight against relinquishing any part of the work.

In the first case, the delegation of the work makes the task of the supervisor more pleasant, as he has more time and energy to concentrate on those duties he cannot delegate. The supervisor, however, cannot completely wash his hands of the responsibility. He is responsible for the work performed by his department or in his department, as well as the scheduling of that work. He cannot sit back and allow the schedule to be his alibi for non-performance of his responsibilities. The schedule will never replace management; it will never replace the supervisor; it is a co-ordinated plan for doing work and must have direction to make it a success.

Obviously, therefore, scheduling cannot work successfully if the supervisor accepts no responsibility. It places the responsibility for operation on the schedule, and, in this fashion, on the planning organization; and neither one has the authority or responsibility to perform the work, so a complete collapse of schedules is inevitable.

In the second case, the supervisor who must run everything and feels he has to do all the work himself, goes to the other extreme. He will not delegate planning

Presented before AISE Annual Convention, Cleveland, Ohio, October 3, 1946

duties; he wants to satisfy everybody because he is sympathetic to any hard-luck story.

On the contrary, why should he be bothered with every little job that someone wants "yesterday"? He should concern himself with orders on his schedule—orders that have been screened out by the planning organization in terms of importance, availability of material, and shop capacity; orders that he or his supervisors have helped schedule with their knowledge of shop operation. The bickering as to which order should be done first, what department should have preference, whether or not material is available, the situation of other shops, and the co-ordination of orders through other shops, are not his problems. He should be acquainted with such problems, yes, but he does not have to worry about them. He has a schedule to follow and it is his sole schedule responsibility to meet the delivery dates. If a breakdown job occurs, it is his responsibility to gear his shop to complete the order as quickly as possible in the most efficient manner. He should not be concerned, except in an advisory capacity, with those functions of planning that are "outside" his jurisdiction; he must, however, have knowledge of those within his jurisdiction.

It is the supervisor in the second case to whom co-operation, in terms of planning, is unknown. He exemplifies the "we do not want to be scheduled" attitude. Therefore, the desire of the shop to be scheduled and to assist in the schedules, and the conviction of management that maintenance shops can be scheduled, must both be present before any type of scheduling is attempted.

The ability of the shop to co-operate is dependent, to some degree, upon the action of the customers, the ordering unit. Likewise, the customer can have a definite effect upon the ability of the planning organization to maintain schedules. How can the customer make or break shop schedules? There is one apparently insignificant thing that most people, who place orders for shop work, forget. All of the planning, routing, estimating, material ordering, scheduling, and dispatching functions are begun and consummated on an order and the information contained in the order. The planning organization has actually only two tools with which to work, the order and the blueprint. The blueprint states the original, new condition of the equipment; the order must state the present condition of equipment and specify what repairs must be made to the equipment. Since there is usually a natural dislike for "paper work," often the least that is possible is placed on the order. The attitude is that if anything is missed or forgotten, the shop will take care of it. How can something that is not known be planned and scheduled? How can the shops do more work than originally requested on the incomplete order and still maintain schedules? It means that work must either stop while emergency plans and schedules are revamped and revised on the spot, or other work must be reshuffled to make machine capacity available.

There is another customer habit that invariably disrupts any well-planned schedule. It is the fire-alarm habit, the hot job, the rush, super-rush and super-colossal rush order. The initial cause for such screamings cannot, perhaps, be eliminated, but they can be handled in such a way to cause the least amount of trouble. The customer who is never satisfied with what he gets, when

Figure 1 — The production order schedule is the master schedule for all orders of this type and contains the material, labor, and shipping requirements for each shop order scheduled for each shop. Each phase of the order is co-ordinated within the schedule to a week-ending date, and released to the shop with definite date commitments.

MAINTENANCE PLANNING DEPT.
PRODUCTION ORDER SCHEDULE

SHOP ORDER NUMBER	SUB NUMBER	ALL HOURS TO BE SHOWN ON THIS SCHEDULE ARE TO BE MACHINE HOURS WHEREVER POSSIBLE. ENTRIES PRIOR TO FINAL SHIPMENT & FINAL SHIPMENT TO BE IN RED PENCIL				TOTAL HOURS SCHEDULED	80	80	80	80	160	80	400	300	300	600	40	40	80	40	RESP. BOI2 DELIVER		SHIPPED (✓)
		MTCE. PLAN.	PROD. PLAN. PRT. LAB.	PROD. PLAN.		TURNS SCHEDULED WEEK	5	5	5	5	5	5	5	5	5	5	5	5	5	5			
		MATERIAL	HEAT TREAT	FORGE PRESS		DAY	F	F	F	F	F	F	F	F	F	F	F	F	F	F			
						OPERATION	LBA	TH	SC	SC	RAD	OAM	AW	AW	AW	AAM	TW	TW	BU	BRZ			
		P.O. No.	No. Pcs.	P.O. No.	No. Pcs.	P.O. No.	No. Pcs.	1A	1B	2A	2B	2D	3A	4A	4B	4C	4D	5A	5B		FROM RESP.	TO RESP.	
13319	A	HEADS 73M632	36																		CY 36	8190	
13319	A	WRAP STOCK	160			WRAP DO 2661	160														BSY 160	8190	
13319	A	WRAPPERS										160									8190 160	3550	
13319	A	END STOCK	27							160		128									BSY 27	8190	
13319	A		ENDS							160											8190 160	8190	
13319	A	BOXES						36						36							8190 36	40.H. 3Y	9
SUB TOTAL HOURS							40		60		128		72										
TOTAL HOURS							40		60		128		72										
TOTAL HOURS OF INCOMPLETE SCHEDULE																							

WELDING SHOP - WEEK ENDING _____

he gets it, who always has a job that is "going to shut the mill down," should stay out of the shops. The shops are interested only in knowing his requirements, if they are as important as he says. They have a schedule to meet. The customer, instead, should take his problem to the planning organization so they can intelligently discuss the shop schedule, show him what it would involve to "jam" his job in the shops, and show him when he can have his job completed. The job, if important, can be planned just as easily as a less urgent one. And if true that the "mill is going down" if the job isn't taken care of at once, any or all jobs can be stopped in the shop to do his work. The essential factor is that all work that is stopped can be continued again on a planned revision to schedule, because of prior and complete knowledge of the breakdown requirements. This is exceedingly important. Rather than have a complete disruption of schedule because planning has not allowed for the breakdown, the schedule is merely halted for the time required to perform the emergency work. This is true maintenance of schedules.

Throughout this discussion, the planning organization has been mentioned time and time again. It might appear in the discussion that management, shops, and customers can do so much to prevent scheduling that there is no room for anyone else. This is not true. The planning organization itself can do as much to prevent successful scheduling as all three of the others combined. A planning organization must have a good reputation. Not necessarily a reputation based on successful accomplishments, but a reputation based on a willingness to do all they can for anybody, to go out of their way to be of service, and to render service over and above that required—a reputation, in short, that has developed because the personnel of the organization are not afraid to create more work for themselves by going off the beaten path to give service.

A planning organization that does things when it says it is going to do them, which admits its mistakes and makes an honest effort to stop their recurrence, can virtually write its own ticket for the co-operation it requires of management, shop, and customer. This is an ideal situation, but it cannot be maintained unless the planning organization is able to back up its velvet glove attitude by means of the steel fist inside. We do not mean this to be as dictatorial as it may seem, but the planning organization cannot allow itself to be the welcome mat for everyone to walk over. This may very well be the tendency; not that the customer or shop intentionally means to take undue advantage of the co-operation they receive, but they are naturally inclined to follow the path of least resistance. There is such a thing as too much service, which makes it too easy on one side with the resultant tremendous increase of work on the other.

On the other hand, if you have a planning organization that is, or has a tendency to be, the diametrical opposite of this, you simply do not schedule maintenance shops. This goes back, again, to the adage "practice what you preach." A lax or dismal attitude in the planning organization will definitely create a similar attitude in the other three sides of planning, to the extent that they will simply refuse in a subtle manner to co-operate. To refuse to co-operate is to refuse to schedule.

Another of the principles which is of tremendous assistance in scheduling maintenance shops is the "principle of preferential orders". The sequence of receipts of orders has very little, if anything, to do with processing sequence. One customer may have had his order in for weeks, yet it is constantly set back in schedule because of more urgent requirements of another customer. Thus urgency of the requirements as related to unit operation becomes the guide for "which job should be worked on first." The fact that orders have been placed for any length of time has no effect on the guide except when "urgency" has been handled. How, then, can the insistent demands of shops' customers be answered when each request must apparently be completed within a week's time, and there are more such requests than any shop could do in six months, even if they received no more orders?

It is necessary, therefore, for the planning organization to determine the relative importance of each order from each customer, and then correlate these with the shop or shop capacity for any definite period of time. Obviously, no planning organization is, or will ever be, able to determine this within its own responsibility. Just as obviously, the person who can establish the relative importance of jobs from one unit, is the person in charge of that unit, or the man in charge of the repair and maintenance of that unit. Therefore, the responsibility for determining which job is the most important to the operation of the unit and which job should be processed first, is that of the ordering unit.

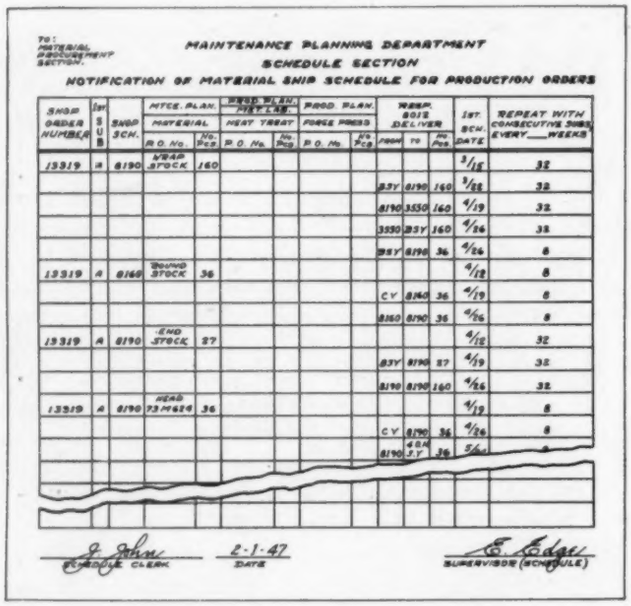
This responsibility cannot be taken lightly, especially when shop capacity is considerably below the demand for any period, because guessing may result in serious delay within a unit due to not having the right equipment repaired at the right time.

The final decision as to which order to process first, with successively less important orders in 2, 3, 4 order, is the principle of preferential orders. Such a sequence of orders for any unit cannot be construed, in any way, to mean that the orders will be completed in this exact sequence. It is a guide to be used by the planning organization to process and schedule orders and is exact only within the bounds of control of the planning organization.

The relative importance of each order for each ordering unit should be transmitted to the planning organization at the end of each week, for the following week's application. This list should be established on a weekly basis at the start to allow the greatest amount of flexibility. By flexibility I mean ability to add and/or change orders and preference rating easily without causing drastic changes in the manner of processing or the location in the schedule of orders. The list should be prepared in quadruplicate and contain the following minimum information:

1. *Preference number* — The orders do not need to be listed in preferential sequence but each must carry a preference number, starting with the number one and running consecutively to the last order.
2. *Shop order number* — Each order must be identified by number, code, or combination of both, depending upon the identification system used.
3. *Responsibility, department or unit number* — As each department head may have a number of sub-heads for various units, each should be identified individually for control and statistical purposes.

4. *Requested delivery date* — The need for delivery date on each order may seem to be in conflict with the preference number. This, however, is not the case. Due to various reasons, it may be, and often will be, possible to schedule order number ten long before order number one. However, from the ordering unit's standpoint this may be both impractical and undesirable. Thus, the delivery date indicates the most desirable time for order completion.
5. *Scheduled delivery week ending* — The information required on the preference list as described in 1 through 4 above and 6 to follow, is to be supplied by the ordering unit. The "scheduled delivery, week ending" item is the responsibility of the planning



TO: MATERIAL PROCUREMENT SECTION

MAINTENANCE PLANNING DEPARTMENT
SCHEDULE SECTION
NOTIFICATION OF MATERIAL SHIP SCHEDULE FOR PRODUCTION ORDERS

SHOP ORDER NUMBER	DIV SUB	SHOP SCH.	MTCE. PLAN. MATERIAL P.O. No.	No. Pcs.	PROD. PLAN. HEAT TREAT P.O. No.	No. Pcs.	PROD. PLAN. FORGE PRESS P.O. No.	No. Pcs.	WKSP. SCH. DELIVER FROM	TO	No. Pcs.	INT. SCH. DATE	REPEAT WITH CONSECUTIVE SHED. EVERY ___ WEEKS
13319	A	8190	HEAD STOCK	160								3/15	32
									837	8190	160	3/28	32
									8190	3550	160	4/19	32
									3550	837	160	4/26	32
									837	8190	36	4/26	8
13319	A	8160	BOXING STOCK	36								4/12	8
									CV	8160	36	4/19	8
									8160	8190	36	4/26	8
13319	A	8190	END STOCK	27								4/12	32
									837	8190	27	4/19	32
									8190	8190	160	4/26	32
13319	A	8190	HEAD 73M624	36								4/19	8
									CV	8190	36	4/26	8
									8190	4 OM 37	36	5/4	8

J. John — 2-1-47 — E. Edge
CLERK — DATE — SUPERVISOR (SCHEDULE)

Figure 2 — This form is essentially an outline of the material and shipping requirements for each scheduled order, as a means of transmitting the details of the schedule from the master order schedule, maintained by the planning section, to the material schedule, maintained by the material procurement section. The relationship between the production order schedule, this form, and the material schedule for production order, is readily apparent.

organization. It is to notify the ordering unit that the order has been scheduled for a definite date (within the week ending on a certain date in this case), and that the order should not be included again in any succeeding lists. Orders that do not have a scheduled date indicated are to be repeated on the next list, and are not scheduled, primarily because they exceed the unit's shop capacity allotment for the predetermined period.
6. *Description of requirements on shop order* — Experience has proven that discussion of any order by its identification number, even with planning and shop personnel, is not always satisfactory. A brief description makes identification much easier.

One copy of the list is retained by the sub-department or unit head as a means of record of each order requested, as well as a record of the relative preference numbers in case additional orders must be inserted during the effective week. Before progressing any further in this discussion, we want to caution you who are sub-department heads, that every effort must be made to have this list absolutely correct in every detail, and to be positive that you have adequately planned your list to obtain your most important requirements. There is a very good reason for this. Unless the list is very small, all the orders indicated will not be scheduled because of the limitations of shop capacity and the necessity for an equitable allotment of this capacity. Also, if the list is not correct for your requirements, and changes must be made after the list is released, it will invariably mean that you must replace order for order from the list. Such corrections, in addition, cause a considerable increase in the work of the planning organization and the shop and usually require schedule changes.

The remaining three copies of the list are to be forwarded to the department head who must correlate each list in such a manner that sufficient shop work is directed to the unit or units that require more service. The list also enables the department head to obtain a bird's-eye view of the shop requirements of each of his units. The department head is to remove one copy of each list for his file and forward the remaining two copies to the planning organization.

A typed or pencil hectograph master is to be made of each list, when received by the planning organization, by transcribing the information to a second sheet. This sheet should be organized so that the information to be transcribed is in the same order as the original list, except that the space containing the description is arranged for the insertion of the estimated hours for each shop on each order.

Sufficient copies of these sheets should be duplicated and distributed to all sections of the planning organization for immediate use. Each section is to be guided by this list in processing whatever orders they may have that appear on the list. Remember, the preference list does not imply completion by numbered sequence; it establishes the relative importance of orders and the tentative processing sequence.

As it would be physically impossible for the shops to work on all orders shown on the preference list, the orders must be selected on the basis of preference number up to the total number of shop orders allotted to each ordering unit. The planning organization, therefore, must indicate on the sheets, the total allotted hours for each shop for that particular unit, and, against these totals, list the estimated hours for each shop on each order. The number of orders that completely utilize the total allotted hours for each shop are the orders that are to be scheduled for that ordering unit. Basically and simply, it is a question of having a certain number of coupons representing shop hours for each ordering unit. These coupons are torn off for each order from the ordering unit in terms of the number of hours each shop must spend on the order, and only the most important orders are to be considered in utilizing the coupons. The orders that have been selected on the basis of importance and the availability of the shop hours required to produce them, are not necessarily to be scheduled for the same week as the preference list indicates. Due to the nature of most repair and maintenance jobs, this would be impossible. No, these orders

have merely been selected for scheduling. They must now be fitted into the schedule at the earliest time, to maintain as much of an uninterrupted flow through the shops as is possible, in preferential sequence. The important point is that, regardless of when the orders are scheduled for delivery, no more hours are scheduled than are available in any shop in each week.

The scheduled delivery dates of the orders are to be indicated on the two copies of the original list, and one copy returned to the ordering unit as indication of schedules and of those orders that must again appear on the preference list. One copy should be filed in the planning organization as a matter of record and as reference for discussions involving schedules.

Considerable mention has been made of the allotment of shop hours, and we have explained how allotted hours and the preference list are co-ordinated. Now, what is this allotment of shop hours?

It is usually impossible to give each ordering unit all of the work they demand, and it is not fair to give more to one unit than to another except as the actual need is apparent. There is a means, however, of hitting a fair average and giving the most work where it is actually needed. It is logical to assume that if the ordering units have been operating successfully for an extended period, such as through the war years, at a high rate of operation, then they have been getting sufficient work from the shops to at least cover their minimum requirements. On this basis, from past records of shop labor distribution, determine the number of hours each ordering unit received from each of the shops for a month, based on at least a twelve month average. The hours of work received from each shop are a certain percentage of the total labor hours spent by each shop for that period.

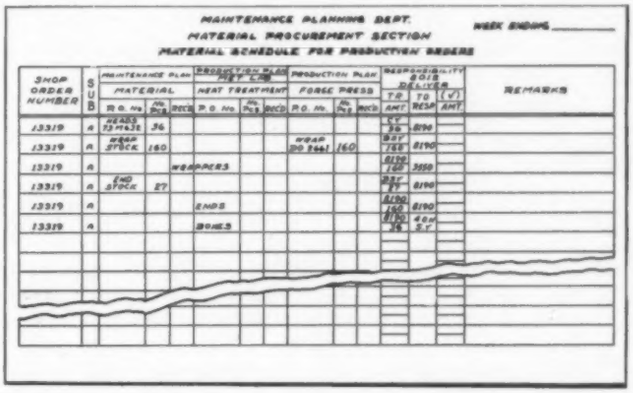
Each ordering unit's percentage of hours for each shop applied to the current month's or week's total number of labor hours to be spent in each shop, determines the allotments of that ordering unit for the month or week, whichever is desirable. The accuracy of past records more or less determines the accuracy of this system.

Each of you may well raise a question as to the advisability of using a flat percentage for distribution of shop hours, regardless of the level of operation or any other circumstances that would easily upset the balance maintained by a flat percentage. We believe your question can be answered in this way: essentially the allotment system, like the preference list, is a guide; it cannot be a hard and fast rule and, therefore, accuracy is not of paramount importance.

We believe it is vitally necessary to repeat the fact that the allotment of shop hours in application should be used only as a guide in the distribution of the total expendable hours in each shop. Logically, more hours cannot be distributed than are available for distribution. Actually, the number of expendable shop hours to be considered depends upon the percentage of these hours utilized in shop work that is estimated. We have assumed that it is apparent that shop work cannot be distributed to ordering units unless the amount of hours required to complete any one order is known in advance. This can be determined only by past records or by estimating, or best, by a combination of both.

The reason for stress on the "guide" use of allotments, is that it is not desirable to establish a bank account for each ordering unit to record hours borrowed from another unit to cover emergency or breakdown work that would exceed the month's allotment. To keep an account of such loaning and borrowing so each unit receives its original allotted share involves an uneconomical clerical expense and considerably more "paper work". It is necessary to apply the allotments impartially at the start of each new period and to attempt to hold to them except in cases of emergency requirements. The end of the period may find the distribution fairly off-standard, but drastic variations are more the exception than the rule.

The co-ordination of preference lists and allotments to the actual schedules for maintenance shops may seem somewhat obscure but we believe it can be understood in this fashion. By means of the preference lists, you establish the relative importance of each order which more or less establishes a priority on the orders in 1, 2, 3 sequence. By means of the allotment, you select from each list the number of orders that will equal the ability of the shop to produce during a given period; and by

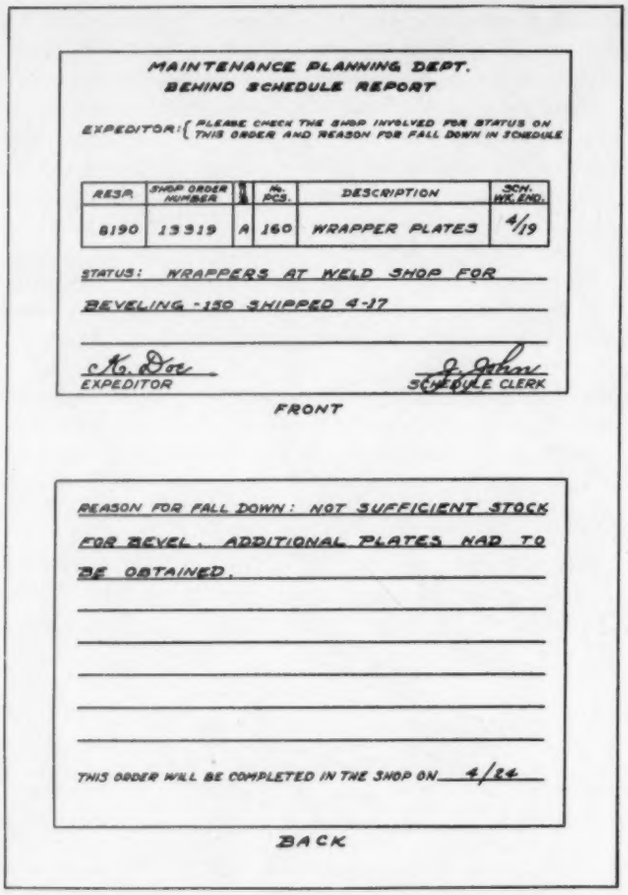

MAINTENANCE PLANNING DEPT.
MATERIAL PROCUREMENT SECTION
MATERIAL SCHEDULE FOR PRODUCTION ORDERS
WEEK ENDING _____

SHOP ORDER NUMBER	SUB	MAINTENANCE PLAN MATERIAL P.O. No.	No. Pcs.	DESCR.	PRODUCTION PLAN HEAT TREATMENT P.O. No.	No. Pcs.	DESCR.	PRODUCTION PLAN FORGE PRESS P.O. No.	No. Pcs.	DESCR.	RESPONSIBILITY DATE DELIVER TO AMT.	TO RESP.	(✓) AMT.	REMARKS
13319	A	HEADS 12-14-16	36								6/7 36	8190		
13319	A	WRAP STOCK	160					WRAP 20 3661	160		6/27 160	8190		
13319	A			WRAPPERS							6/30 160	3558		
13319	A	END STOCK	27								6/27 27	8190		
13319	A			ENDS							6/30 160	8190		
13319	A			BOXES							6/30 36	404 S.F.		

Figure 3 — This form is a condensation of the master order schedule, emphasizing the material requirements, auxiliary services of heat treatment and forge press, and shipping instructions. The latter requirement is a responsibility of the material procurement section.

means of a schedule, you direct the shop production in a co-ordinated plan that will economically and efficiently complete the orders in the shortest amount of elapsed time. This may leave you with the impression that such a schedule is for the same week as the effective date of the preference list, and in some ways it is. It is a schedule for the effective week in that the selected orders and hours are scheduled that week to represent tentatively a week's work in the shops; however, they may be scheduled for completion any time from the effective week to one year, depending upon the circumstances. Thus, if you schedule a week's work each week, regardless of the completion date, and you completely utilize the shop capacity each week, you will receive a week's work for each week of operation over an extended period. This actually is a delayed return. You invest shop hours this week for a return some time in the future. If this is done each week, at those future dates you will receive a return in work of a week's shop hours.

The word "schedule" has been used rather promiscuously in this discussion and it is essential that some



MAINTENANCE PLANNING DEPT.
BEHIND SCHEDULE REPORT

EXPEDITOR: { PLEASE CHECK THE SHOP INVOLVED FOR STATUS ON THIS ORDER AND REASON FOR FALL DOWN IN SCHEDULE

RESP.	SHOP ORDER NUMBER		No. PCS.	DESCRIPTION	SCH. WK. END.
8190	13319	A	160	WRAPPER PLATES	4/19

STATUS: WRAPPERS AT WELD SHOP FOR BEVELING - 130 SHIPPED 4-17

M. Doe
EXPEDITOR

J. Johns
SCHEDULE CLERK

FRONT

REASON FOR FALL DOWN: NOT SUFFICIENT STOCK FOR BEVEL. ADDITIONAL PLATES HAD TO BE OBTAINED.

THIS ORDER WILL BE COMPLETED IN THE SHOP ON 4/24

BACK

Figure 4 — The necessity of an expediting medium, in event of an anticipated schedule fall-down, as a means of schedule control is apparent. Confirming information must be available for explanation of behind schedule orders in regular schedule meetings.

investigation be made of it. Frankly and honestly, we cannot tell you now to schedule your maintenance shops. Many people think, mistakenly, that a scheduling system that is successfully operating in one company can be transplanted effectively into a different company. The truth is, it cannot be moved intact to a similar company. Any scheduling system must be developed to meet existing conditions and circumstances in each shop, and as these are diversified and of various intensities in every company, any total adoption is apt to fail. However, as each system is basically the same, varying more in application than in principle, we can provide some pointers that will assist in the development of a scheduling procedure.

First of all, and of paramount significance, do not expect miracles of a schedule unless you expect and demand miracles of your planning organization and your shops.

From the standpoint of shop operation, scheduling of maintenance shops must perform two primary functions to be effective. First, it must develop a predetermined delivery date of completed work, through planned and co-ordinated routing of shop operations, consistent with shop practice and capacity. This development must be accomplished without regard to the emergency and breakdown job as it affects the continuity of schedules, but not as it affects the portion of shop capacity allotted to complete ordinary repair and maintenance in the shops. Second, it must establish a control of the movement of work in process by which the continuity of schedules will be maintained after the disruption of emergency and breakdown work. With this function it should tend to prevent the disruption of schedules by other than emergency work. The schedule, in short, must control the interventions of such work and the continuation of scheduled work after completion of the emergency.

Very briefly, the mechanics of scheduling consist of three major sub-developments:

1. Material delivery schedules.
2. Planning, routing, and estimating.
3. Shop schedules and dispatching.

Thus, scheduling should, in general, follow these steps:

First, determine from a complete analysis of each order what material must be obtained from sources of supply other than stock. Include in this determination the decision as to whether the part or equipment required can be purchased complete more economically and more readily than making it in the shop.

Then, control and schedule the delivery of outside purchases, particularly castings and forgings, by determining the tonnage capacity per month you can depend on from regular suppliers, and place no more for delivery in any one month than these suppliers can produce. Enforce delivery by suppliers on or about the promised delivery date by an adequate follow-up system which works only on the principle of exception. That is, the planning organization should be advised by the supplier only when he cannot meet the requested delivery date; it is not necessary to be notified when delivery will be made on or about the required date. In the delivery date given to the shop scheduler, sufficient time must be anticipated for shipping, so that he may enter the order in schedule for a starting date after the receipt of material, not before.

Plan, route, and estimate each order individually to each shop involved without regard to other orders. Each is a separate job and must be handled as such. The shop scheduler has the responsibility for correct and efficient utilization of shop equipment. Each piece of equipment required on an order must be set up on an individual shop routing except where more than one shop must perform work on the same piece, and where knowledge of shop operation and common sense indicate otherwise.

Particular care must be exercised to prevent errors in planning and routing in order that required operations are not omitted. If such omissions occur frequently and consistently, they will cause schedule deviations and possibly "fall-downs".

The planning, routing, and estimating are vital to successful scheduling and require a fairly thorough knowledge of shop operations and practices. This work requires basically the ability to mentally perform each operation that the mechanic will perform physically and mentally in the shop.

Separate continuous manufacture orders from repair and maintenance orders. They are two different and distinct types of orders and cannot be handled in the same manner. Continuous manufacture orders should be discussed with the shop general foreman in detail, since the schedule of such orders, once established, is

not changed except for cancellation of orders, increase or decrease in quantity and time of delivery, or unpredictable emergencies.

The shop general foreman, and his subordinates, should actually indicate the establishment of the schedule for continuous manufacture orders.

A considerable advantage in machine or load center utilization will be realized, both for continuous manufacture orders and repair and maintenance orders, if the former are confined entirely to a certain machine or machines. These machines should be restricted to this work, except when open capacity is available for other types of work. Once production schedules are established on these machines, they can be disregarded more or less in repair and maintenance order scheduling.

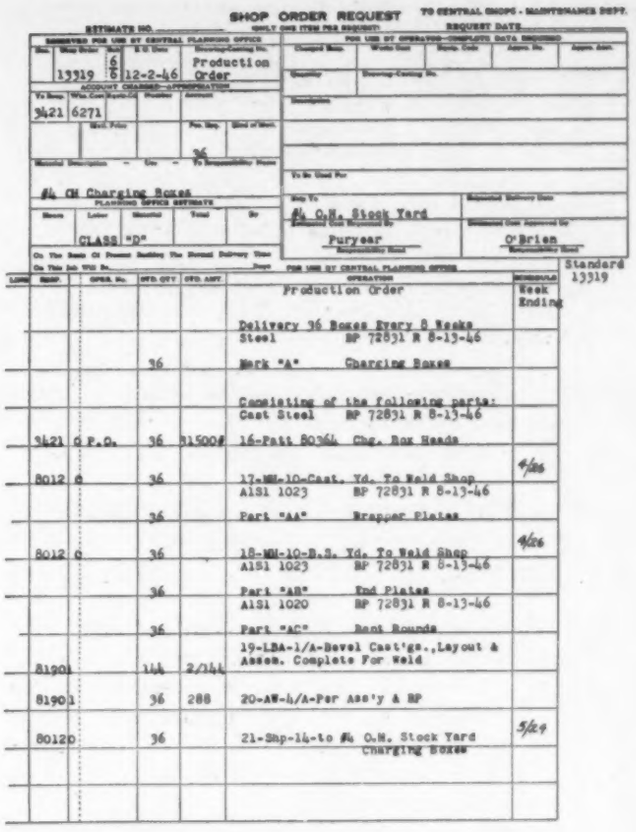
All material required for continuous manufacture orders should be stocked to eliminate any possibility of schedule disruption due to lack of material. It is actually a question of providing material to meet a shop schedule, rather than providing a shop schedule when material is available.

Repair and maintenance schedules, on the other hand, are a job-to-job proposition. Each order is a new schedule that must be co-ordinated to other orders in an existing schedule. A study of past experience with material deliveries will reveal that each type or kind of purchased material can be anticipated within a certain time after placement of orders with various suppliers. This average time should be used by the scheduler to set up tentative schedules that reserve shop capacity at some future period. In the majority of cases, delivery of material prior to the expectation of this normal delivery time will not necessitate changes in advance schedules. Every effort should be made to allow sufficient advance scheduling to eliminate any need for changing pre-determined schedules.

The scheduling of shop work itself is the translation of machine or man hours into available capacity to maintain adequate backlogs or loads and to provide a constant, or at least intermittent, progress of each order. Due to the variable nature of jobbing work, it is desirable to allow a day in the schedule for each movement of work from one shop to another and to develop completed job delivery dates on a week ending basis only. This open method of scheduling provides a cushion for emergency work over and above that anticipated, so as to eliminate unnecessary and numerous schedule changes.

Weekly schedules should never be corrected during the effective week of processing, which means that a current week of schedules must not be physically changed. If current order progress information indicates an overload of shop capacity due to inherent errors in time estimation, or extraordinary emergency work, the schedule for the next week or succeeding weeks should be lightened in an amount equal to the current week's overload. Conversely, a light current week's schedule should be strengthened by overloading the succeeding week. In effect, such a practice is to extend the weekly schedule to a two-or-three-week-period schedule.

A serious mistake often made in maintenance scheduling is the belief that direct machine scheduling can be and should be performed by the planning organization or other personnel outside of the shop proper. This



SHOP ORDER REQUEST — TO CENTRAL SHOPS - MAINTENANCE DEPT.

ESTIMATE NO. — REQUEST DATE

Dept.	Work Order	Sub	E.O. Date	Drawing-Casting No.
	13319	6/6	12-2-46	Production Order

ACCOUNT CHARGED—APPROPRIATION

To Store	Who Can Approve	Requisition	Amount
3421	6271		

Unit Price		Per Hrs.	Hrs. of Work
		36	

Material Description — Size — To Responsibility Stores

#4 CH Charging Boxes

PLANNING OFFICE ESTIMATE

Hours	Labor	Material	Total	By
	CLASS "D"			

On The Basis Of Present Backlog The Normal Delivery Time On This Job Will Be _____ Days

Changed Name | Works Cost | Repair Code | Approx. No. | Approx. Amt.

Quantity | Drawing-Casting No.

Description

To Be Used For

Ship To: #4 O.H. Stock Yard

Requested Delivery Date

Requested Cost Recommended By: Puryear

Requested Cost Approved By: O'Brien

FOR USE BY CENTRAL PLANNING OFFICE

Lgng	Shop	Oper. No.	Std. Qty	Std. Amt.	Operation	Schedule Week Ending
					Production Order	
					Delivery 36 Boxes Every 8 Weeks	
					Steel BP 72831 R 8-13-46	
			36		Mark "A" Charging Boxes	
					Consisting of the following parts:	
					Cast Steel BP 72831 R 8-13-46	
3421	6	P.O.	36	31500#	16-Patt 80364 Chg. Box Heads	
8012	6		36		17-MH-10-Cast. Yd. To Weld Shop	4/25
					AISI 1023 BP 72831 R 8-13-46	
			36		Part "AA" Bracket Plates	
8012	6		36		18-MH-10-S.S. Yd. To Weld Shop	4/26
					AISI 1023 BP 72831 R 8-13-46	
			36		Part "AB" End Plates	
					AISI 1020 BP 72831 R 8-13-46	
			36		Part "AC" Bent Rounds	
8190	1		144	2/144	19-LBA-1/A-Bevel Cast'gs.,Layout & Assem. Complete For Weld	
8190	1		36	288	20-AW-4/A-Per Ass'y & BP	
8012	0		36		21-Shp-14-to #4 O.H. Stock Yard Charging Boxes	5/29

Standard 13319

Figure 5 — The focal point of scheduling endeavor is the release of the scheduled order to the shop. This order must contain accounting information, operation routing, estimated time, specific instructions, material requirements, delivery instructions, and schedule dates.

approach will produce undesirable results. True, schedules to machine groups can be developed by a unit outside of the shops, since sufficient general shop knowledge is available for this broad scheduling. However, individual machine scheduling can be developed only in the shop itself. This is the sole responsibility of the shop foreman. He is the only person close enough to shop operations to have detailed knowledge of the various factors that make the difference between good and bad shop efficiency and production. He must know what work is to be done by his people, as well as what work is to be done in the machines, and what is a better method of keeping up on this than the actual scheduling of the operations within his jurisdiction?

Obviously, however, with the vast amount of other work he must do to maintain his operations, it is impossible to expect him to handle all the details of scheduling of work in his section. For this reason, there should be personnel from the planning organization, called "dispatchers," assigned to each shop. The function of the dispatchers is primarily to assist the shop foreman in the scheduling of work and to perform all of the clerical work that is necessary with scheduling. The dispatchers can and should handle routine and repetitive orders, but the foreman should handle all other orders with the assistance of the dispatchers when requested. The final approval of all schedules however, rests with the foreman.

DISCUSSION

PRESENTED BY

L. S. STEINER, Assistant Superintendent of Maintenance, The Timken Roller Bearing Company, Canton, Ohio

W. W. JUSTICE, Superintendent, Service Department, Carnegie-Illinois Steel Corporation, Youngstown, Ohio

L. E. FULLER, JR., Superintendent, Maintenance Planning Department, Carnegie-Illinois Steel Corporation, Chicago, Illinois

E. B. RUSSELL, Youngstown Sheet and Tube Company, Youngstown, Ohio

M. G. SMITH, Bethlehem Steel Company, Bethlehem, Pennsylvania

L. S. Steiner: Mr. Fuller has certainly given us a fine paper on a timely and important subject, one that might well be studied by anyone interested in the orderly and efficient operation of a maintenance shop. However, the natural sequence to such a fine paper might well be the question, how do we do it? What are the mechanics involved in setting up an organization to implement the ideas which Mr. Fuller has propounded?

It would seem to me that the operation of a maintenance shop resolves itself into three distinct problems which we might call preparation, execution and delivery. Let us look at these items separately: The first item, preparation, is of paramount importance, and it is upon this that the success or failure of a scheduling system to a large extent depends. First, it involves the receipt of materials; no material should be brought into the shop for repairs until clearance has been given by some responsible party. This function should be performed by a maintenance scheduler or person with some similar title. This party, through his contacts with the shop foreman, superintendent of maintenance and management, would be in a position to know when this material could and should be placed in schedule and processed. Unless this is done, the shop soon becomes a catch-all for every piece of equipment that someone wants repaired whenever time is available.

Any material coming into the shop should be properly identified. A satisfactory method seems to be to attach a substantial tag to the equipment giving a brief description, location and repairs required. This tag should have several detachable portions with similar information, one for the shop foreman, one for the maintenance scheduler and one to be retained by the originator for his records. This will insure the scheduling of the equipment at the proper time, and in case of smaller pieces may prevent them from becoming lost.

The maintenance scheduler, acting as a clearing-house, should notify the parties involved on any particular piece of equipment who should see that proper instructions are issued and correct drawings and other information are available for the job. Materials coming into the shop on outside purchases such as castings, gears, etc., should be inspected by some competent person and his findings reported to the planning department, so this material might be placed in schedule at the proper time.

This all important first step, if well done, will insure a smooth flow of materials through the shop and allow the shop foreman and his assistants to devote all of their time to overseeing the execution of the work, which is step two.

Step three might seem unimportant but in order to keep an orderly, efficient shop, all parts should be removed as soon as they have been completed. The shop should never be used as a storehouse for either finished or unfinished materials.

If these three steps are kept in mind and scheduling is done along the lines suggested by Mr. Fuller, our maintenance shops should operate at top efficiency, but obviously this cannot be done unless full co-operation is given by the shop, planning department, and customer, along with the full support of management.

W. W. Justice: There was a point brought out in the paper that, generally speaking, there was about six months' backlog ahead of the shop. It would be impossible to fill everybody's orders when they really wanted them, so you had to set up a priority system.

After all, a plant has to run and you have to do all the work that has to be done in any one year. Why can't the shop be arranged in such a way that if somebody wants something in a week or so, he can get it?

L. E. Fuller: The shop can be arranged in such a way to handle any request within a week or so, although the schedule, more than the shop, must provide for such interference.

The schedule must provide availability of machine hours by loading machines up to, say, 80 per cent of operating capacity, allowing 20 per cent to be used on orders of the type you have mentioned. The schedule must also have a flexibility of operation that will aid the required changes in scheduled orders that must take place when an emergency order exists. Obviously, a large number of orders that must be completed within a very short time, will cause serious trouble with the schedule and the shop. You will find, however, one of two conditions prevalent in such a case as just mentioned. Either the emergency orders are justified by actual breakdowns in equipment, and you must do your best to maintain a schedule regardless of the changes; or your schedule is not operating efficiently.

Experience has indicated that the number of emergency orders subsides considerably when you are in a position, as a result of scheduling, to forecast a completed date on orders and maintain these dates. Therefore, if the emergency orders begin to increase, and you feel they are not all of this class, immediately investigate your schedule efficiency.

So far as the backlog of orders is concerned, a schedule will never make it possible to do all the work requested of a shop, until the supply of man-hours in the shop somewhat equals the demand for man-hours. The schedule can only be based on the present operating capacity of the shop and cannot attempt to arrange more work than the shop can handle in a given period.

W. W. Justice: I do not know what happens to the backlog you have today if he waits six months for his job. You still have six months or eight months then.

L. E. Fuller: If you are fortunate to be plagued very little with orders that interrupt your schedule, your

backlog should turn over constantly. The greater the backlog, the longer it will take to turn over. If, however, you have interruptions, as you are bound to have, there will be a number of orders, dependent upon the number of interruptions, that are constantly set back in the schedule, and work on them is actually never started. This situation, from the schedule standpoint, cannot be corrected as long as the demand exceeds the supply of shop man-hours.

Obviously such work must be completed, as the more often it is set back in schedule, the more likely it will develop into an emergency order and interrupt your schedule. One solution to this situation is the responsibility of the planning organization. If the producing capacity of the shop is not great enough to handle the volume of orders, then other sources of capacity must be located. The planning organization should have contacts with other suppliers as a means of reducing the backlog of work and provide all repairs and maintenance requested.

E. B. Russell: I would like to ask about what per cent of shop capacity is used on an average? Do you operate on a 24-hour basis, or part time?

L. E. Fuller: At the present time, our shops are operating on a two-turn basis. The reduction from a three-turn to a two-turn basis was necessary because of a man-power shortage, more than any other factor. The per cent of shop capacity utilized, of course, is dependent, first, on the amount of work required within a given period, and second, the availability of man power in the shop.

M. G. Smith: Mr. Fuller, how many men do you have in your production department, and what is the size of your shop as far as man power is concerned?

L. E. Fuller: We have eight shops that are handled by the planning organization:

Carpenter	Approximately 78 men
Pipe	Approximately 148 men
Welding	Approximately 206 men
Blacksmith	Approximately 88 men
Boiler	Approximately 139 men
Rigger	Approximately 78 men
Machine	Approximately 490 men
Locomotive and car repair	Approximately 102 men

Within the planning organization, we have a total of 70 persons which includes 13 men in the material handling yards, 10 in the material procurement section, 16 in the spares control section, and 31 in the planning and scheduling section.

Four of the eight forementioned shops, welding, blacksmith, boiler, and machine, require most of the effort of the planning organization as they handle the greatest amount of shop work.

M. G. Smith: That is a very high percentage of your total force then, isn't it?

L. E. Fuller: No, I do not believe it is unusual. When you consider all eight of the shops, the percentage is approximately 5; calculated on the four major shops, it is 7.5 per cent.

Member: In starting up your maintenance plant, as far as your original schedules were concerned, with what did you start as a possibility for schedule in your shops? Would you say that you schedule 50 per cent and allow 50 per cent for emergencies, and how long a period of time did it take you to move up, or have you moved up on the amount that you can schedule?

L. E. Fuller: An investigation of our past experience indicated that approximately 50 per cent of the shop's capacity was utilized on regular repair orders, 20 per cent on emergency orders, 20 per cent on "petty" orders, and 10 per cent on standing orders.

Petty orders, requiring less than 8 man-hours to complete, are not scheduled. Such orders are the responsibility of the shop to fit into the schedule when the opportunity presents itself.

Standing orders cover requests for shop service that cannot be readily estimated, such as electrical maintenance inspection, and also production items such as crane points, chisels, stoppers, rods, etc. The latter items are scheduled.

Actually we have never reached 50 per cent of shop capacity due to the partial inflexibility of our present physical scheduling methods. I have mentioned before that the physical means employed to schedule the shops must be exceedingly flexible to enable the planning organization to readily adjust the schedule to compensate for interruptions. The approximate 30 per cent of capacity we did reach has not been maintained, and we are now in the process of revising our scheduling methods to introduce a more flexible system.

M. G. Smith: Are you attempting to schedule to a certain machine rather than full shop schedule?

L. E. Fuller: We are attempting to schedule to machine groups or load centers only. The distribution or scheduling of work to a particular machine within a group or load center is handled within the shop, primarily by the shop foremen.

Member: Is it a fact that you are only able to schedule 30 per cent due to the fact that the operating maintenance group or the operators cannot forecast their needs far enough in advance?

L. E. Fuller: No, I do not think it is primarily due to that factor, although it has a large effect. It is impossible for the operators and operating maintenance men to completely forecast their needs far enough in advance to reduce schedule interruptions. They can, however, by constant review of their apparent needs, reduce the number of interruptions considerably.

Accepting the fact that interruptions to a schedule cannot be eliminated, our problem is, I believe, in answer to your question, again the factor of flexibility. Assuming a scheduling system that has the ultimate degree of flexibility, you should be able to meet most emergencies and still maintain schedules by rapid and correct revisions. Without this ability, you eventually find your schedule completely muddled.

E. B. Russell: You mentioned estimating. How do you set up for that? Does your scheduling department do the estimating or your operating, or your shops, or a combination of all three?

L. E. Fuller: We have a group of eight men, who are called "planners", in the planning and scheduling section. It is desirable to have men in this group who are trained journeymen, and we have been able to fairly well maintain this standard.

These men establish the material required to perform the work required by the order, the operations to be performed by each shop on the material, the routing of the work through each shop, and the approximate man-hours or machine hours to complete each operation.

SCALE REMOVAL AND SURFACE PREPARATION *with Sodium Hydride*

. . . . the sodium hydride process, because of its speed and because of its reducing action on the scale alone without affecting the base metal, is finding many applications in the steel industry . . . .

By H. L. ALEXANDER
Manager, Metal Descaling
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▲ THE use of sodium hydride to remove mill and process scale and to prepare metallic surfaces for industrial operations is one of the most recent and novel developments in the iron and steel industry. The introduction of the sodium hydride descaling process marks the beginning of another advancement in the processing of ferrous, as well as many of the non-ferrous, metals and alloys.

Figure 1 — Testing the sodium hydride content of the bath is a simple operation.

Sodium hydride is a strong reducing agent and is employed in this process to reduce metallic oxides such as annealing and mill scale, thereby expediting the cleaning of metals and alloys during their processing and fabrication into finished articles. Sodium hydride actually works in reverse as compared to the oxidizing action most metals undergo when exposed to air at room or elevated temperatures. Most scale-forming oxides are reduced to the base metal; oxides of metals which form acid radicals are partially reduced, in which case the action is sufficient to produce entirely satisfactory results.

Fused caustic soda heated to 700 F is used as a carrier bath for the sodium hydride. The sodium hydride concentration is maintained within the range of 1.5 to 2 per cent by weight and is produced "in place" by reacting metallic sodium and hydrogen in open bottom chambers partially immersed in the bath.

All metals and alloys which do not react with fused caustic soda and whose physical characteristics are not adversely affected by the temperature of the bath (700 F $\pm$ 20 F) are amenable to treatment; those materials which react slowly may be treated if satisfactory descaling can be accomplished during a short treating cycle.

Material is processed by a single treatment of short duration in the sodium hydride descaling bath. This is followed by a water quench and rinse which either completes the cycle or prepares the work for subsequent operations.

The sodium hydride descaling process is covered by patents held by the E. I. du Pont de Nemours and Com-

Presented before AISE Annual Convention, Cleveland, Ohio, October 1, 1946

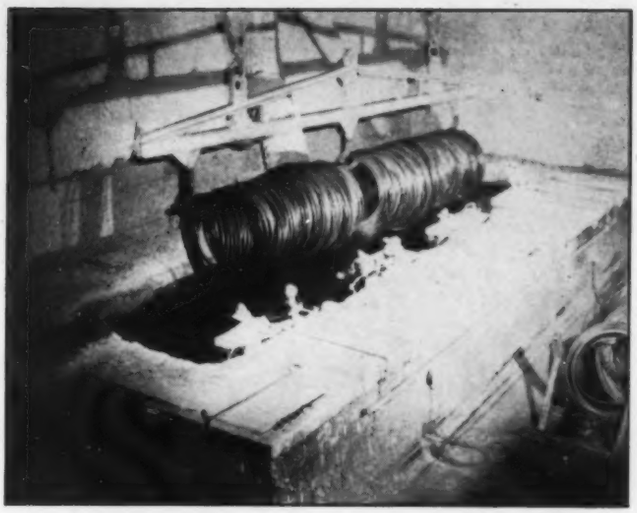


Figure 2 — A 3000 lb batch of stainless steel rod is being lifted out of the sodium hydride bath.

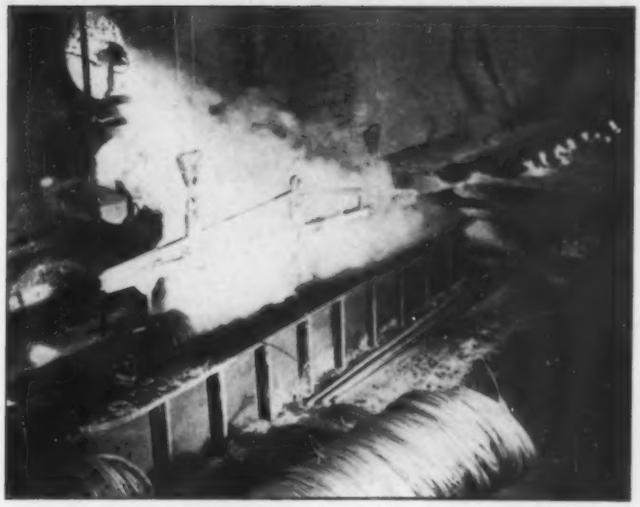


Figure 3 — A batch of rod is being lowered into the water quench.

pany, Inc., Wilmington, Delaware, and is available to companies within the United States which are interested either for laboratory or commercial application. Neither license nor royalty agreement is required to operate this process.

HISTORICAL BACKGROUND

In the early stages of laboratory development, metallic sodium, known to be a good reducing agent was employed in an attempt to reduce oxide scale. Difficulties were encountered in uniformly wetting the scale with the sodium. When a reaction did occur, the reduction was accompanied by the formation of corrosive sodium oxide. The excess sodium was difficult to remove from the treated work, and a special technique was required to operate a molten sodium bath at elevated temperatures in the presence of air.

A bath of fused caustic containing molten sodium was tried next but was impracticable due to the accumulation of sodium oxide and large quantities of sludge. This bath readily dissolved scale constituents, but attacked the walls of the tank used for the experiments, as it was extremely corrosive to iron and steel.

Further experimental work demonstrated that sodium hydride dissolved in fused caustic readily reduced iron oxide to metallic or elemental iron. The sodium hydride in reacting with the scale formed caustic soda which was the material comprising the carrier bath.

It was also found that nickel and cobalt oxides were reduced to their respective metallic states, while chromium trioxide (chromic oxide) was reduced to the lower oxide, chromous oxide, but not to the metallic state. However, it was observed that complete reduction of scale was not essential for efficient treatment.

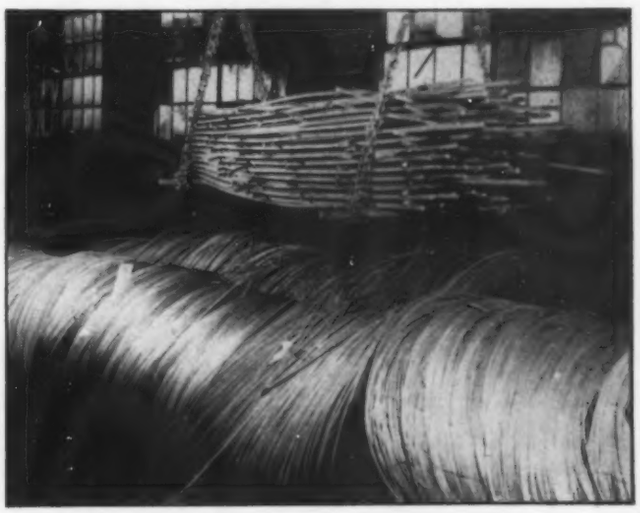
Reduced oxides of 18-8 stainless steels remained on the work in a finely divided condition as it was taken from the sodium hydride, caustic soda bath. Reduced material remaining on other metals and alloys varied in quantity and in form ranging from finely divided powder to large foil-like patches.

It was observed that steam generated during water quenching of the still hot metal blasted off a considerable amount of the reduced scale. The work was then subjected to a high pressure water rinse to remove any water containing caustic soda carried from the quench tank and to wash off loosely adhering material. In order to eliminate the last traces of this reduced material and to obtain a bright surface, the work was immersed in acid for a short period and again rinsed with the high pressure water spray.

The work was now free of scale; here appeared to be the essentials of a cleaning process ideally suited for preparing steels for inspection, drawing, cold rolling or other operations.

Next the details necessary to translate these laboratory results to practice were investigated. The sodium hydride used in the experiments was not commercially available at that time, and it was decided to determine the possibility of forming hydride by reacting sodium and hydrogen in the bath. A series of experiments demonstrated that an efficient bath could be prepared most economically in equipment similar to that now

Figure 4 — This assorted lot of stainless steel wire, rod and bar stock has been descaled by the sodium hydride process.



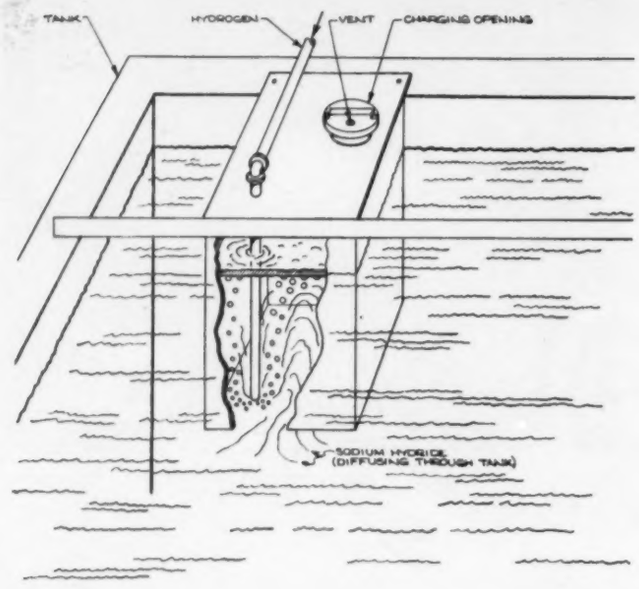


Figure 5 — The sodium hydride generator box is mounted on brackets on the side of the tank.

used. Hydride baths thus prepared reduced the scale in an identical fashion.

This development work and initial commercial applications of the process in the United States were under the direction of Dr. Harvey N. Gilbert, supervisor of the sodium and cyanide products research, Electrochemicals Department, E. I. du Pont de Nemours and Company, Inc., Niagara Falls, New York, with the laboratory assistance of Mr. N. D. Clare. Dr. Gilbert was recently awarded the Jacob F. Schoellkopf medal for 1946 by the Western New York Section of the American Chemical Society for his contribution to metal descaling practice through the development of the sodium hydride descaling process and for other outstanding research in the production, handling and utilization of metallic sodium.

STATUS IN INDUSTRY

The sodium hydride descaling process has been used commercially since 1941. The economic feasibility and the attractiveness of the process were demonstrated in several plants during the past war and by continued use since V-J Day. In spite of the wartime shortage of sodium, several steel companies working on high priority projects were able to install the sodium hydride process, since it was considered so essential to their effective operation. With the end of the war the limitations were removed, making possible a rapid expansion of this use of the descaling process for a wide variety of applications.

The following list gives a breakdown of the present plant size installations of the sodium hydride descaling process; large tonnages are processed in all but two of these units:

No. of units	Form of material
6	Wire.
3	Sheet.
3	Job descaling.
2	Bar.
2	Castings.
1	Forgings.
1	Fabricated parts.

Companies now operating, descale the metals and alloys included in the following list:

1. N.E. steels.
2. S.A.E. steels.
3. Carbon steels.
4. Cast iron and steel.
5. Chrome stainless steels.
6. Chrome-nickel stainless steels.
7. High speed tool steels.
8. Silicon steels.

Materials included in the above list are processed in the following physical forms:

1. Rod.
2. Wire.
3. Bar.
4. Strip.
5. Cog stock.
6. Breakdown plates.
7. Plates.
8. Sheet.
9. Composite sheets.
10. Castings.
11. Forgings.
12. Stampings.
13. Fabricated parts.
14. Welded and brazed parts.

Additional sodium hydride descaling baths are now being installed to process various metals and alloys in prime producing mills, as well as galvanizing, heat treating, welding and fabricating plants.

CHEMISTRY IN THE BATH

Sodium and hydrogen react directly to form sodium hydride as shown by the following equation: $2\,Na + H_2 = 2\,NaH$. Theoretically, each pound of sodium requires

Figure 6 — The water quench tank should have about the same dimensions as the descaling bath.

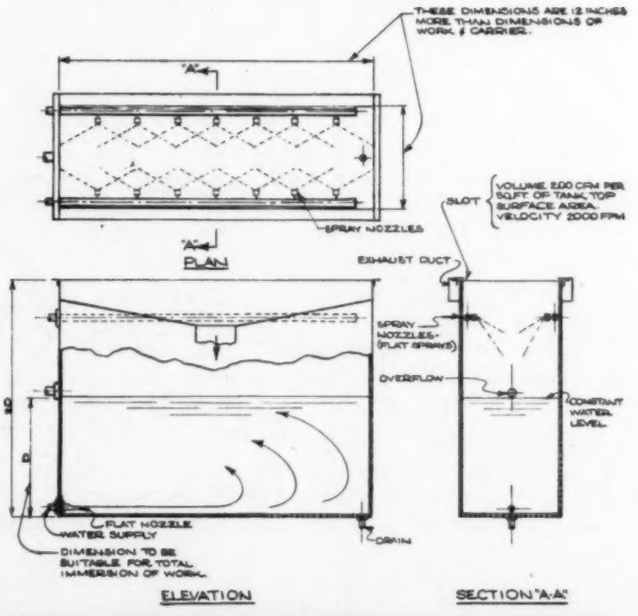


Figure 7 — The final rinse is made with high pressure water.

Figure 8 — A 2½ lb brick of metallic sodium is being fed into the generator.

7.8 cu ft of hydrogen. When dissociated ammonia is employed as the source of hydrogen, approximately 12 to 15 cu ft of the dissociated gas (75 per cent H_2 and 25 per cent N_2 by volume) are required. Sodium hydride, dissolved in the fused caustic carrier bath, diffuses from the bottom of the generator as it is formed. It is then distributed uniformly throughout the bath by the convection currents without auxiliary means. The sodium hydride bath is quiescent and does not give off irritating fumes or vapors; consequently, hooding is unnecessary. The concentration of sodium hydride in the descaling bath may be determined readily by means of a simple gas evolution method.

Sodium hydride reactions with scale are illustrated in the following equations:

A. $4\ NaH + Fe_3O_4 = 3\ Fe + 4\ NaOH$

B. $NaH + CuO = Cu + NaOH$

C. $NaH + Cr_2O_3 = 2\ CrO + NaOH$

Equations A and B illustrate complete reduction, while equation C is an example of partial reduction. The sodium hydride reduces the scale in all cases to the metal or lower oxide, simultaneously forming caustic soda. Since the carrier bath is caustic soda, no undesirable materials are formed which necessitate replacing the bath.

TESTING

As previously mentioned, the sodium hydride content of the bath is maintained at from 1.5 to 2.0 per cent by regulating the sodium and hydrogen feed rates. A check on the hydride concentration may be made quite readily by means of an easily performed test.

A 2-gram sample is obtained by ladling a portion of the bath into a small split mold. This sample is placed in a gas evolution apparatus which quantitatively measures the hydrogen given off when the sample is dissolved in water.

The operator reads the sodium hydride content of the bath directly in per cent from calibrations on the bell collector. The analysis is entirely a matter of gas evolution and measurement and is run at the scene of the descaling operation (see Figure 1).

Testing is quite simple, requiring from 3 to 5 minutes to run the complete analysis. With average conditions, this analysis would be made three times per shift. The apparatus is commercially available.

TREATING CYCLE

A typical treating cycle consists of the following steps:

1. Sodium hydride treatment.
2. Water quench.
3. Wate rinse.
4. Acid dip.
5. Water rinse.

Work to be processed is placed in baskets or on suitable racks as shown in Figure 4; careful arrangement is unnecessary provided the bath has free access to and from the surfaces requiring treatment. The work is then lowered into the bath until the reducing cycle is complete. Factors such as the type of metal or alloy, the kind and amount of scale and the size of the object, govern the length of treatment. Only a few seconds are required for individually treated light weight articles which quickly come to bath temperature, while ar icles such as heavy forgings and castings may require up to 30 minutes. Treating times may be established readily by experiment and usually range from 8 to 20 minutes for large scale batch operations.

When the scale is completely reduced, the work is removed from the bath, allowed to drain and, while still hot, immersed in water (Figure 3). A large portion of the reduced material is dispelled during this operation.

A rinse utilizing a high pressure water hose is employed to remove loosely adhering material and any remaining caustic soda.

Bright surfaces such as those required for drawing, rolling and forming operations are produced by a short dip in acid. This step may be eliminated when parts are

cleaned prior to inspection, machining and the application of hot dip coatings.

Rinsing again with the high pressure water hose removes the smut and acid remaining after the brightening dip, and a bright clean surface is obtained (see Figure 4).

EQUIPMENT

Caustic-hydride tank — An all welded low-carbon steel tank is used to hold the bath. The tank is mounted in a suitable setting with the top approximately 3½ ft above floor level. Facilities must be provided for heating the bath to 700 F ± 20 F and have sufficient capacity to replace the heat absorbed by the work within an acceptable period. This tank temperature is measured and controlled by a controlling-recording pyrometer having a range of 500 to 1000 F. Sufficient heating surface should be provided to restrict the maximum heat transfer rate to 10,000 Btu per square foot per hour. Direct flame impingement on the heating surfaces should be avoided to prevent localized overheating. This may be done by any of the standard methods of heating salt baths which include (1) externally fired furnaces using gas or oil as fuel; (2) internally fired immersion tube furnaces using gas as a fuel; and (3) in electric furnaces heated externally by resistance elements or internally by immersed electrodes or resistance elements. It is desirable to provide a sufficient volume of bath to control the temperature drop within certain limits when work is introduced. Units embodying the various means of heating mentioned above are now operating successfully.

Sodium hydride generators — Generator boxes are made of ordinary carbon steel plates, which are mounted on brackets along any one side of the caustic tank (see Figure 5). A pilot light should be provided to ignite the slight excess of gas as it leaves the generator.

Light weight tongs for handling sodium during the charging operation are necessary.

Dissociators — Dissociators for cracking ammonia can be obtained as standard equipment from a number of manufacturers. A maximum flow of 150 cu ft per hr of "cracked gas" is required for each generator box. Many plants have dissociated ammonia available for annealing purposes. In these cases it is possible to divert a portion of the cracked gas for use in the sodium hydride descaling process.

Gas flow meter — One meter capable of measuring the total amount of hydrogen or dissociated ammonia used is required. This should be so placed that the operator can observe the gas rate to the generators at regular intervals. Hydrogen flow is best regulated by means of needle valves.

Floating pan — During shut-down or extended idling periods a floating pan is put into service to protect the bath from oxidation. This pan is fabricated from carbon steel sheet.

Sludge pan — A perforated sludge collecting pan which rests on the bottom of the descaling tank is used to catch and subsequently to allow the removal of reduced material which may fall off the work during treatment. Dredging methods are feasible should the collector pan prove impractical.

Water quench tank — A water tank of approximately the same dimensions as the descaling bath is required. A sketch of such a tank is shown in Figure 6. It should be located a safe distance from the hydride bath. The customer has a choice of materials from which to construct this tank; however, welded steel plate construction is preferred. Ventilation facilities should be provided to remove steam and spray formed during the quenching operation.

Acid tanks — When acid tanks are required, they should be approximately the same dimensions as the descaling bath. These tanks are of standard construction for the particular acid used.

Rinse hose — A high pressure (100 to 150 lb per sq in.) water rinse hose should be available for rinsing off any smut remaining on the work after treatment.

RAW MATERIALS

Sodium — This is used in the form of 2½ or 5 lb bricks which are shipped in returnable steel barrels

Figure 9 — The finished wire is here shown after the brightening dip.

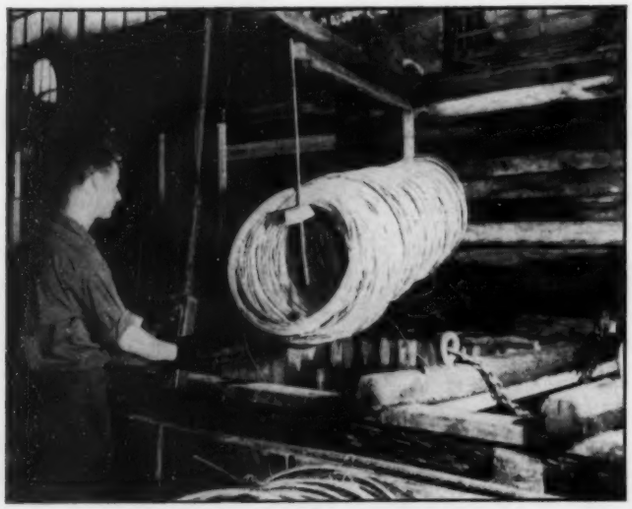
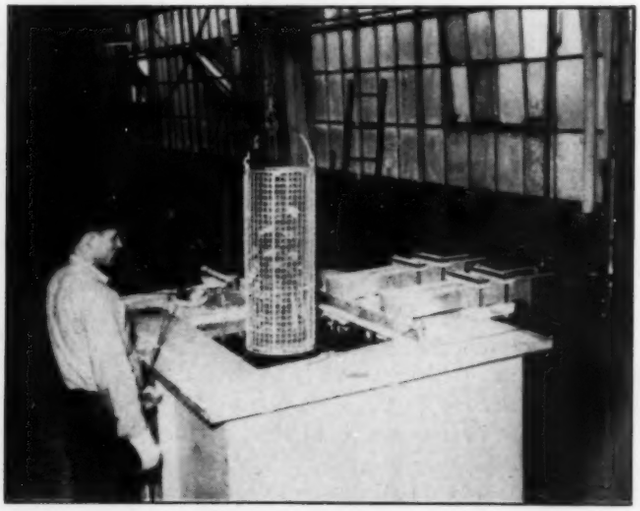


Figure 10 — The sodium hydride treatment can be advantageously used in removing the final traces of imbedded sand and scale particles in complicated castings.



containing 280 lb sodium net. Approximately 6 to 12 lb of sodium are used per ton of descaled metal.

Hydrogen — The most economical source is that obtained from dissociated ammonia; however, any dry gas mixture containing hydrogen which is free from oxygen, CO, and CO_2 can be used. Nitrogen and low percentages of hydrocarbons are not objectionable. Cylinder hydrogen is practicable for use in small installations.

Caustic soda — An initial bath of fused caustic soda is required, for which commercial caustic soda (sold on a 76-78 per cent Na_2O basis) is recommended. The amount of caustic soda needed is calculated on the basis of 112 lb for each cubic foot of bath.

PLACING UNIT IN OPERATION

Either flake caustic, solid caustic, or a combination of the two, may be used in preparing the fused bath. Fused caustic at 700 F weighs approximately 112 lb per cu ft as compared to 133 lb in the cold solid state. This should be taken into consideration when placing the initial charge of caustic into the tank. Sufficient caustic is charged to the tank to bring the salt level to 6 inches below the top of the larger tanks and somewhat higher in smaller tanks, depending on their size.

After the original melt is in place, little or no additions are required as caustic soda is produced as the by-product of the descaling reaction. The amount formed usually compensates for the amount lost by dragout.

Dehydration — Caustic retains a small amount of water even in the molten state, but it must be rendered anhydrous before any attempt is made to generate sodium hydride. The recommended method for dehydration is the addition of sodium monoxide to the melt. The sodium monoxide is poured into the bath and then stirred until dissolved. Dehydration is indicated by an unmistakable color change, and the color of the melt progressively changes from the original brick red through chocolate brown to black.

Hydrogen — All hydrogen and dissociated ammonia lines are purged until no explosive gas mixture remains in the system. Generator feed covers are removed during this operation and care is exercised to prevent the occurrence of explosions.

Starting generators — A brick of sodium is added to each generator as shown in Figure 8, allowed to melt and ignite. The burning sodium will consume the oxygen present in the generator. The charge hole cover of the generator is placed in position and after approximately two minutes the cover is removed and a lighted torch is inserted into the box to check whether or not the atmosphere within will support combustion. If the torch does not burn in the generator, the cover is replaced and the hydrogen gas flow is started. The excess gas passing from the generator is ignited and the flow rate adjusted to the anticipated sodium feed rate.

Hydrogen flow and sodium feed rates are correlated. One pound of sodium must have a minimum of 7.8 cu ft of hydrogen, and inasmuch as the hydrogen does not react with 100 per cent efficiency, it is necessary to use a slight excess.

Sodium feed when operating — To charge sodium, a lighted torch is placed near the sodium charge hole so that it will ignite the gas within the generator when the cover is removed. The sodium is then added, the cover replaced and the off-gas ignited.

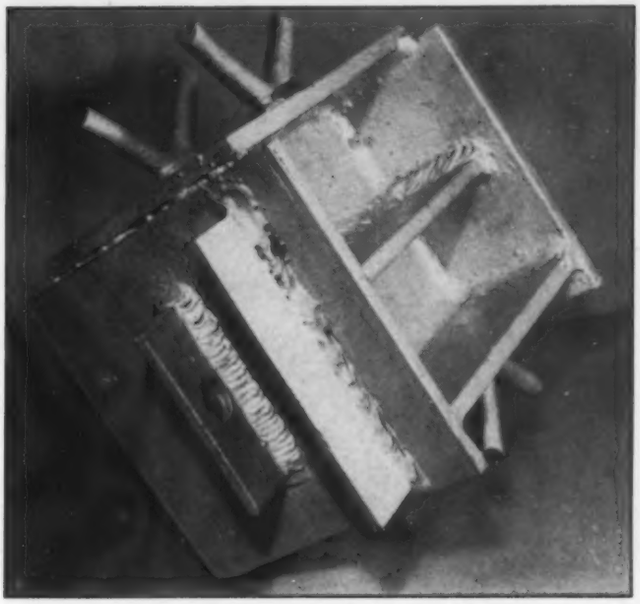


Figure 11 — This specimen was descaled by the sodium hydride process before galvanizing.

Floating pans — The floating pans are put into service during the initial sodium hydride build-up period. This is an economy and a time saving measure as the pans will reduce surface oxidation and the desired hydride content will be attained with a minimum amount of sodium and hydrogen.

Treating work — The rack is loaded, checked for the presence of moisture and if dry, introduced into the bath. Wet materials are "baked" in suitable drying ovens. The length of treatment necessary is determined by experiment; however, for bath operation 8 to 20 minutes are usually sufficient to reduce heavy scale. Lightly scaled materials require proportionately shorter treatment.

The rack is then removed from the tank and excess drippings are allowed to drain into the tank when the bath is below the desired level. Otherwise, it should be drained on the adjacent caustic drip pan.

The subsequent water quench should be at a rate which produces a minimum amount of splashing. After the quench, it is advisable to rinse the work in water to remove excess caustic.

Brightening in suitable acid, shown in Figure 9, plus a water rinse completes the cycle.

Temperature — The temperature is maintained between 680 and 720 F. This temperature range is important and must be maintained if optimum results are to be obtained.

OPERATING PRECAUTIONS

The usual safety precautions when operating fused baths must be observed. It is essential that water does not come into contact with sodium. Sodium barrels,

both empty and full, should be stored in a dry clean room having a good roof. The room must not have an automatic sprinkler system and water must not be used in the sodium storage area.

Operators should wear goggles or face shields and wear clothing to fully protect their bodies when working near the bath. Goggles or face shields should also be worn when handling sodium, particularly when opening sodium drums.

APPLICATIONS

A new commercial application of the process, which has been in use since early this year, is in the final desanding and descaling of intricate castings, such as pump heads and other similar castings which must be thoroughly cleaned before final assembly. The hydride treatment is used following normal sand or shot blasting operations and is used as a means of removing final traces of imbedded sand and scale particles. The hydride treatment cannot be used as a means of primary sand removal.

Interest is also being shown for this type of usage prior to machining operations such as broaching and other operations involving high tooling costs where imbedded sand is extremely injurious to tool life.

Another new application of the sodium hydride descaling process has been recently developed. A midwestern manufacturer uses a proprietary paint as stop-off for the selective carburizing of various steel parts, making possible large savings of time and money in its manufacturing operations. However, the resultant scale formed on these parts following heat treatment is extremely difficult to remove by normal methods as it contains considerable amounts of finely divided silicious and copper material. It was found that treatment in the sodium hydride bath not only completely reduced the scale present but also removed all traces of the silicious material. A treatment of approximately 10 minutes in the sodium hydride descaling bath followed by a water quench produced a clean part suitable for further machining operations. Equipment for this particular installation has been ordered and will probably be put into operation in the near future.

The use of the sodium hydride treatment for descaling prior to plating is also of considerable interest. In many cases it is possible either to completely eliminate acid or to confine its use to a short final dip prior to actual plating operations. The process is particularly effective in descaling parts of intricate shape. New applications are being inaugurated whereby the process will be used advantageously for this purpose. Recently, improved electroplated coatings of nickel were observed when some small heat treated closure buttons previously descaled were plated by a New England concern. Batch anodic cleaning in baskets produced only fair cleaning on the inner surfaces. When cleaning was done with sodium hydride these surfaces were cleaned as well as the outer ones since effective descaling is attained wherever sodium hydride has access.

Another use for the process which is proving very effective is for descaling prior to hot dip galvanizing. Objects ranging in size from nuts and bolts to structural members are projected for treatment in installations now in progress. Treatment in the sodium hydride bath

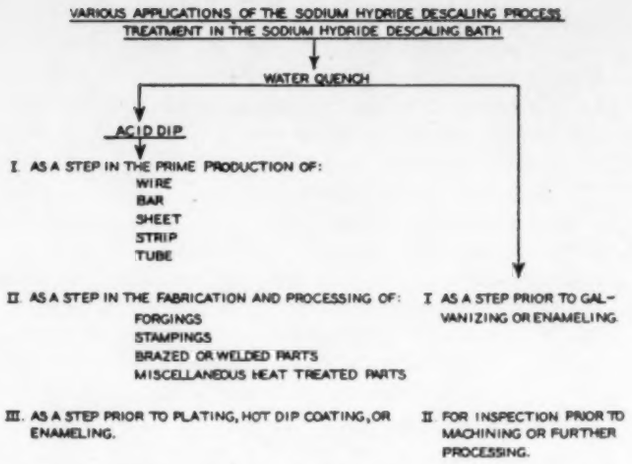

VARIOUS APPLICATIONS OF THE SODIUM HYDRIDE DESCALING PROCESS
TREATMENT IN THE SODIUM HYDRIDE DESCALING BATH
WATER QUENCH
ACID DIP
I. AS A STEP IN THE PRIME PRODUCTION OF:
WIRE
BAR
SHEET
STRIP
TUBE
II. AS A STEP IN THE FABRICATION AND PROCESSING OF:
FORGINGS
STAMPINGS
BRAZED OR WELDED PARTS
MISCELLANEOUS HEAT TREATED PARTS
I. AS A STEP PRIOR TO GALVANIZING OR ENAMELING.
III. AS A STEP PRIOR TO PLATING, HOT DIP COATING, OR ENAMELING.
II. FOR INSPECTION PRIOR TO MACHINING OR FURTHER PROCESSING.

Figure 12 — The sodium hydride descaling process has found many uses.

followed by a water quench and then a dip in a suitable flux makes possible an extremely sound bond between the zinc and base metal.

A welded structural steel section was prepared in order to determine the effectiveness of sodium hydride descaling prior to hot dip galvanizing (see Figure 11). Seven types of coated welding rods were used in making this specimen. Poor welding technique was purposely employed for making many of the welds. Correct, as well as low and high heats were employed using a-c and d-c current. Large and small beads, undercutting and rough welds were made in the different welding positions.

All scale and flux were removed satisfactorily by a 15-minute treatment in the sodium hydride bath plus the usual water quench. An acid dip was unnecessary prior to the fluxing and galvanizing steps.

Lower dross losses, savings of acid and zinc, and fewer rejects are among the advantages sodium hydride descaling will offer in this application.

To summarize, applications for the sodium hydride descaling process are found in industry as indicated by Figure 12, and Figure 13 shows the effectiveness of the treatment.

FEATURES

1. Descaling proceeds uniformly on all surfaces wet by the bath.
2. All analyses of steel are amenable to treatment. Types normally difficult to descale by other methods readily respond to treatment by the sodium hydride process.
3. Different analyses of steel and composite materials may be descaled simultaneously.
4. Dissimilar materials may be processed simultaneously and different types may be treated interchangeably.
5. The process is effective for descaling nickel, copper, cobalt and the common alloys of these metals.
6. Careful arrangement of the work is not necessary.
7. Welding scale, drawing compounds and small quantities of paint, oil and grease are removed by the descaling bath.
8. The process can be employed to remove traces of

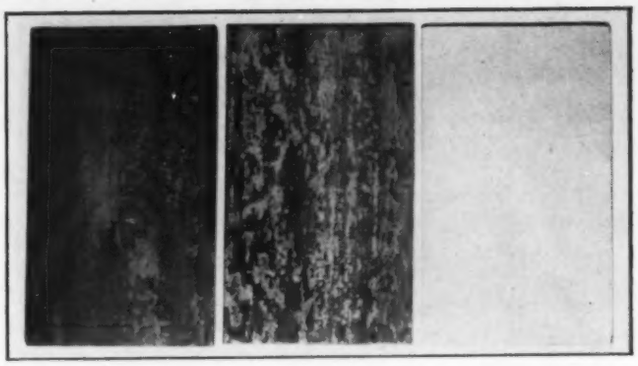


Figure 13 — The condition of 410 type test panels is shown here before treatment, as quenched, and acid brightened.

sand remaining on casting surfaces after primary sand removal with normal cleaning methods such as sand or shot blasting.

9. There is no loss of the base metal since the sodium hydride reacts only with the scale.
10. No pitting occurs and the original dimensions of the work are maintained.
11. The time required to descale is substantially less than with other methods.
12. Overtreatment is not harmful for the reaction stops when the reducing action on the scale is finished.
13. The working temperature of the bath (700 F) is below the operating temperature of competitive processes.
14. The methods regularly used to heat molten salt baths are applicable to the sodium hydride process.
15. No electric current is required to activate the sodium hydride descaling bath.
16. Hydrogen embrittlement has never been encountered.
17. Savings in metal, acid, labor, process time and capital investment are among those possible through the use of the descaling process. Expense and trouble to dispose of pickling wastes are often lessened.

DISCUSSION

PRESENTED BY

J. M. CARRERA, Columbia Steel Company, Pittsburg, California

H. L. ALEXANDER, Manager, Metal Descaling, Electrochemicals Department, E. I. du Pont de Nemours and Company, Inc., Niagara Falls, New York

J. M. Carrera: Is the removal of the sand particles from the castings a reduction process similar to the reaction between sodium hydride and scale?

H. L. Alexander: No, the removal of the sand particles is accomplished through the reaction of the molten caustic, sodium hydride, and sand to form a sodium silicate accompanied by the evolution of hydrogen. Generally, a considerable quantity of sand is embedded in the flakes of scale on the casting surfaces. These sand particles would not be contacted by the caustic bath were it not for the reduction of the scale by the sodium hydride that is present. Thus the combined reaction provides complete sand removal. Because of the quantity of hydride consumed in the above reaction, along with the evolution of hydrogen, the process is recommended only for removing the final traces of sand that remain, following primary sand removal by one of the usual methods such as sand or shot blasting, etc.

Member: Do you have any round figures for comparison of acid pickle costs against the new method cost?

H. L. Alexander: It is rather difficult to give a complete analysis of cost comparing the two processes, but generally I would say the materials cost for the sodium hydride descaling process are slightly higher than for straight acid pickling.

Many of the advantages are more or less intangible and are difficult to show at times, but among the advantages, of course, is the saving of metal. It has been reported, and I think it is a conservative figure, that we save 1½ or 2 per cent of steel. Even these days, that percentage of steel is a nice saving. In many cases, it more than offsets the difference in material costs. Shorter descaling time, more uniformly descaled surfaces and reduced labor costs also come into consideration.

Generally, acid costs of $.50 to $1.00 per ton can be compared with sodium hydride material costs of about $1.50. Of course, in addition to that, in both cases, the costs of heating, labor, utilities, etc. have to be added.

Plan to Attend...

AISE ANNUAL CONVENTION

PITTSBURGH, PENNSYLVANIA

WILLIAM PENN HOTEL

SEPTEMBER 22-25, 1947

MODERN TRENDS IN BRUSH OPERATION

. . . . brush selection should be the result of consideration of all contributing factors, so that the lowest over-all cost is obtained consistent with safe, reliable operation . . . .

BY LEON D. COOK
Supervisor, Attended Substations
Commonwealth Edison Company
Chicago, Illinois

▲ IN order to appraise the trends in brush operation it is necessary to consider some of the recent concepts relative to the passage of current through moving contacts.

During the past twenty years much has been discovered relative to the passage of current between moving contacts. These new concepts have been a contributing factor in solving many of the practical everyday brush operation problems. It is now generally understood that there is little analogy between the action of current transfer on stationary and moving contacts. Profitable discoveries on this problem have been made by a number of independent engineers through research along the following lines: (a) reduction in brush contact surface without load reduction, (b) observing the action of current carrying pin-point probes, (c) discharging condensers at many times normal current through moving contacts and observing the contact pattern, (d) grooving collectors and slotting or otherwise altering the brush faces.

The theories on this subject now in most general acceptance are as follows:

1. All of the current is carried across the contact in the form of an electric arc.
2. The current is carried across the contact by means of solid particles and electric arc in parallel.
3. The current is carried across the contact as a result of thermal ionization and thermal emission resulting from high temperature of the last point of contact.

The reasoning in support of theories 1 and 2 is well stated by Hunter-Brown. "The voltage drop at the contact does not vary proportionally with the current, but remains remarkably constant over a wide range, and there is for each brush a critical value below which no current will flow. In this respect the behavior somewhat resembles that of an electric arc where there is a certain minimum voltage below which the arc cannot be maintained." Other investigations show that there

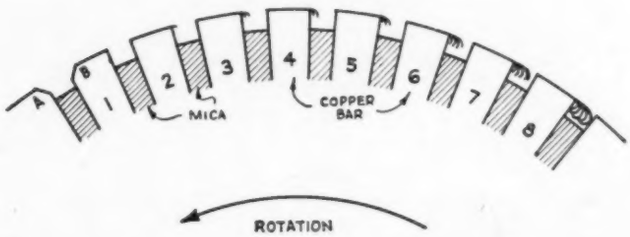


Figure 1 — The build-up of copper on the trailing edge of the commutator bar may eventually be sufficient to short-circuit the slot.

is a minimum potential across a sliding contact at which no current will flow. Theories two and three are fundamentally the same since they differ only in the manner in which the thermal ionization is produced. That is, the current is increased and heat is generated at the points of contact which volatilizes the conducting material and forms an arc. This process may take place either through a salient point of the brush or across a bridge formed by a carbon particle rolling between the surfaces. Assuming that current can only be carried across a sliding contact on an arc, the corollary follows that the current then must be restricted to a very small portion of the brush surface at a given moment. This would be true because high current densities would be required to maintain the arc at temperatures necessary to volatilize the contact materials.

Mechanical abrasion and the destructive effects of the high local current densities cause constant shifting of these points of contact so that solid contact at any single point of either commutator or brush face is probably of extremely short duration, except now and then at firmly imbedded points which protrude to a substantial degree beyond the surrounding surface. To summarize this discussion it should be remembered that under no circumstances should the action of current through stationary contacts be confused with moving contacts. The fact that current is carried by only a

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small portion of the brush surface at any given moment should be remembered in connection with the more practical aspects of this problem that follow.

Consideration should be given to all the elements that make satisfactory brush operation, for it is not difficult to obtain any one quality at the expense of another equally desirable element. For example, a commutator of the classical chocolate brown color may at times only be had at the sacrifice of brush life and excessive commutator maintenance. The end sought is not one factor, but a number of desirable elements that together contribute to the lowest over-all cost consistent with safe, reliable operation. In the paragraphs that follow, some of the more important elements of satisfactory brush operation are considered.

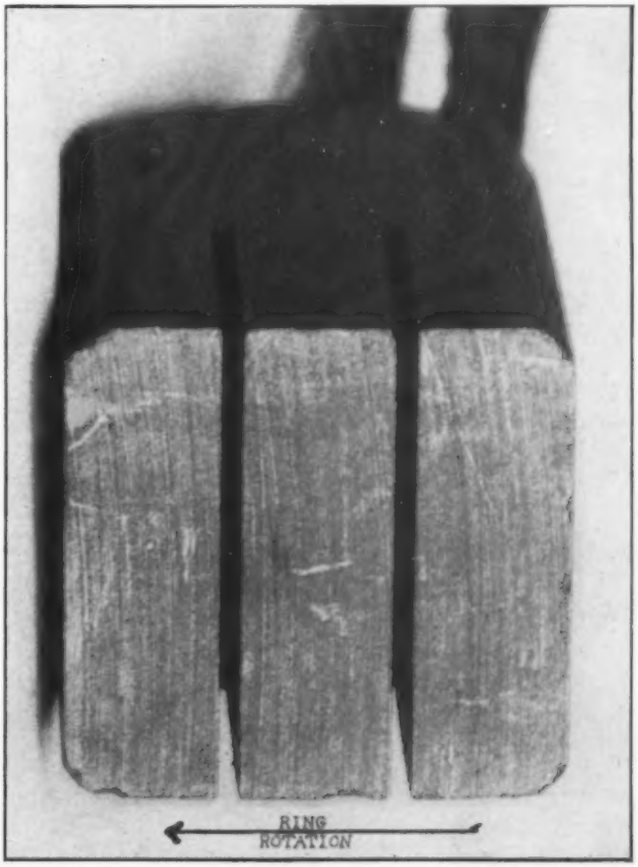
UNIFORM OXIDE SKIN OR FILM OVER COMMUTATOR AND RING SURFACE

The surface skin is not only the most important factor relating to collector wear, but is also the first consideration in the matter of brush life and maintenance expense. The nature of this surface condition and its important contribution to successful operation was not fully appreciated for many years. It is now known that this surface film is not only an indication of, but one of the important factors in successful current collection. The film has the property of enabling the brushes to operate at a relatively low rate of wear. This lubricating property has been shown to be due to a layer of water molecules adhering to, or absorbed on, the surfaces of graphite crystals at the surface of the film. The source of water is the normal moisture in the atmosphere. Herein is the key to why a minimum humidity must be maintained. Should this not be done, the protecting skin is lost and cumulative brush destruction takes place at once. The specific electrical resistance of the film material is much higher than that of the brushes or collector and is a factor which aids in collection, due to the contact drop that results. The thickness of a normal contact film is a few millionths of an inch. However, the thickness may be increased several times by the presence in the atmosphere of certain active chemical substances. The usual variation in thickness of film is the result of brush material or load variation. Usually porous or open grained brushes of lower mechanical strength are associated with the formation of the heavier films more than are the dense brushes. Brushes containing abrasive matter remove film deposit and maintain a lighter, thinner filmed collector. Some brushes must operate at a substantial current density in order to form the desired surface film. At low average density no film is developed by such brushes and film already present may break down, if the lightly loaded period continues, exposing spots or streaks of raw copper. When normal load is again applied, copper is picked from these raw spots before sufficient time has elapsed for the negative brushes to repair or rebuild the damaged film. This copper picking develops fine thread-like grooves over the commutator surface. This type of film breakdown limits the use of brush grades on machines that are at times required to run at light loads. These grades often give outstanding performance when operating under normal load conditions. It is generally thought that this phenomenon of film breakdown at low current density is associated with the high friction of some brush grades at low interface temperatures and the sharp decrease in friction where the interface temperature rises to a critical value. In conclusion of this discussion of collector surfaces, the ideal skin should be such that it can be maintained at a uniform thickness at all times, remembering that the thicker the film is, the more difficult it will be to maintain.

COMMUTATOR SLOTS FREE FROM COPPER OR MICA

"Copper dragging" or "copper foiling" is the term used to describe the condition of copper forming on the leaving edge of the commutator bars. Much maintenance work is the result of this condition, the cause of which is not generally agreed upon. Some engineers are of the opinion that the cause is mechanical, the result of hammer action of the brushes while chattering, causing a plastic slipping of the more ductile metal over the leaving edge of the bars. Others believe the copper displacement is due to electrolytic action within the arc on the leaving edge of the brush, wherein the foil is formed by an electroplating action and then pushed mechanically to the bar edge. Figure 1 shows the progress of copper foil until it fills the slot and

Figure 2 — This brush has been slotted to improve current distribution.



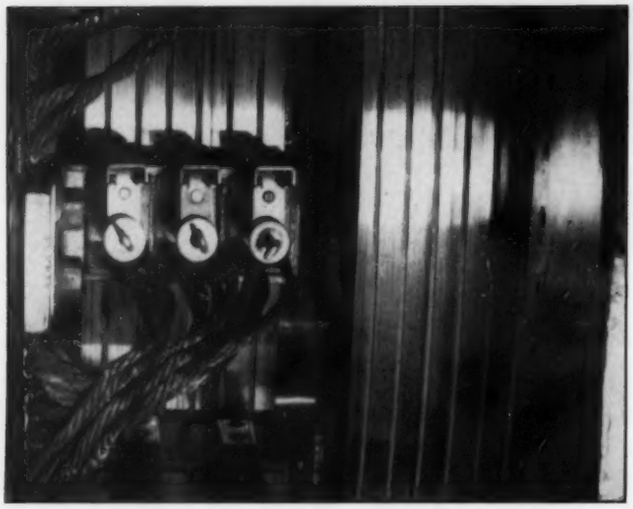


Figure 3 — The rings on this 250 volt, 13,000 ampere rotary converter are grooved.

short circuits two adjacent commutator bars. At bar 5 when this condition is well started it will continue until some bars are shorted. This will be shown by sparking midway between the brush arms, where the voltage between bars reaches its maximum. There may be no sparking at all noted at the brush contact. The progress of this condition can be delayed by thoroughly blowing out the commutator each day. When this is done some bits of foil are removed from the slots. Before the bar short-circuiting stage is reached the commutator should be chamfered as shown at A and B of Figure 1, by removing the corner of the bar with a suitable tool. This must be done to prevent an eventual flashover that will come at a time of minor line or feeder disturbance.

Every effort should be made to prevent the start of copper dragging, for after the amount shown on bar 3 is reached corrective measures are likely to be of no avail. Then the best "cure" for this problem is prevention. The following hints may be classed under this head:

1. Keep the commutator skin of uniform thickness.
2. Copper picking must be prevented.
3. Have tension uniform and keep well regulated.
4. Brushes must be free in the holders.
5. Be sure that brushes and cleaner brushes have no more abrasive than absolutely necessary.
6. See that brushes are not "sloppy" in the holders and that holders are not more than $\frac{1}{8}$ inch from the commutator.
7. Be sure that all arms are properly spaced and that all d-c arm and ring connections are clean and of a uniform low resistance.
8. Brushes should be checked to see that they are in line with the commutator bars.
9. The machine should be run at light load as little as possible.
10. Brush tension should be at the minimum required for good operation.

Satisfactory brush life cannot be expected when mica is allowed to become flush with the copper bars. The most troublesome mica condition met with on undercut commutators is from "mica fins" or "side mica." This is the thin edges of mica along the sides of the slots that are first to cause trouble after some copper has worn away, following undercutting. These thin mica layers are not visible at first glance but are best found with a flashlight that is held so the *side* of the undercut is illuminated. The eye must follow along the length of several bars before the condition of the mica in a commutator can be learned. The presence of mica fins soon after undercutting usually are from one of three reasons:

1. Failure to center the undercutting tool accurately on the mica.
2. Insufficient depth of cut with the V-shaped cutter.
3. Allowing the cutter to depart from a straight line in the traverse of the commutator slot.

Mica is more resistant to wearing action of the brushes than is copper of the commutator bars. If the copper wears even a few ten-thousandths of an inch below the mica, contact between brushes and commutator is disturbed. Sparking, short brush life, bar burning, picking up of copper by the brush faces, and noisy operation are among the difficulties that follow. Proper precaution should be taken after undercutting to insure against troublesome mica fins "coming up" at a later date. The undercutter should always be followed with a hand tool, the sharp hook of which is run along the side of each bar, that is, both sides of each slot (as at A and B of Figure 1), and if any trace of mica is left by the undercutter, it will be "hooked out."

GOOD BRUSH LIFE

Brush life is surely considered one of the most important elements of satisfactory brush operation. In order to know whether the brush life being obtained is satisfactory, records must be kept on the life and performance of various brush grades on different machines. With these data at hand, accurate comparisons can be made as to the performance of different grades under various conditions. It will be seen that records of this kind are invaluable in the intelligent selection of brush grades. When brush life is considered, it should be borne in mind that life is not the whole consideration in grade selection, although in most instances it may be the principal one. The overall cost of operation of the machine in question should constitute the picture as a whole, with brush life as one of the factors. With this in view, due consideration can then be given the matter of grinding, undercutting, bar chamfering, wear of the collector, and flashovers, that all add up to the total expense of operation.

BRUSH HOLDERS

A firm contact between brush face and commutator is essential to satisfactory brush performance. It is this function that the brush holder is called upon to perform. Many brush holders are not of ideal design, so additional care is required in order to insure proper tension and freedom of movement within the holder. The tension steps on many holders are more than one pound per division, requiring additional maintenance care and restricting the use of brushes to grades not sensitive to tension variation. It is quite obvious that in most instances a change in holder design is not economically

practical, so it is up to us to make the best of the situation as we find it.

Where high speed d-c operation is involved, the angle, from radial, at which the brush is set, is of major consideration. The design of most machines does not permit a change in angle. So the angle of operation on this equipment must govern the brush grade used. In some instances the choice is so narrowed that only brushes of rather poor life are practical. It has been proved both practically and theoretically that the ideal angles of operation are 35 to 45 degrees leading on commutator speeds of 4000 fpm or higher, while trailing angles of 15 degrees are superior on speeds of 3500 fpm or less. When brushes are operated at the above angles within the limits prescribed, little consideration need be given the problem of brush stability.

HOLDER CLEARANCE

It is desirable that clearance between the commutator or ring and brush holders is kept nearly constant by lowering the holders as the commutator is worn away. In most cases the ability of the spring to maintain the proper tension, as the brush wears down, is the factor that sets the length to which it is possible to wear the brush. This being true, the distance between collector and brush should be held to a minimum, because this will permit longer wear of the brush. The safe minimum distance at which it is found most practical to place brush holders from the collector, is $\frac{3}{32}$ of an inch. In most instances it will be found profitable to lower the holders when they are up at least $\frac{1}{4}$ inch.

ARM SPACING

Accurate spacing of the brushes or brush arms around the commutator is of importance in obtaining satisfactory brush performance. If the spacing is not uniform, circulating currents will flow between the brush studs of like polarity due to their difference in potential. These circulating currents may be high enough to cause burning of the brush faces and commutator bars. The additional heat is apt to cause serious mechanical trouble in the commutator. This is manifest by warped commutator bars that will be observed to be high at one end or the middle with the remainder of the surface smooth. Furthermore, it is impossible under such conditions, to adjust all brushes to the best commutating position. Should uneven spacing be suspected, a check should be made by placing a strip of adding machine paper entirely around the commutator underneath the brushes and marking it with a sharp pencil at the toe of each brush. Care should be taken that each mark is made in the same manner and that there are no brushes where the toes have been chipped away. Should this check show a greater variation than $\frac{3}{16}$ of an inch, the brush arms should be respaced.

HOLDER ALIGNMENT

In addition to being evenly spaced around the commutator, the edges of the brushes should be accurately aligned with the commutator segments. This can be determined by observation of the row of brushes and also indication on the brush face at the salient point. This condition is sometimes caused by the holders being sprung out of line, possibly by standing on them. Another cause is warping at the insulating blocks where the brush arm connects to the machine frame. The correction in the first instance is to spring or shim the holder back into line; the second is corrected by shimming the arm at the point of support. There is no definite point of alignment where it can be said repairs should be made, because some machines are more sensitive to this adjustment than others. Therefore, the seriousness of this condition can only be determined by the magnitude of the resulting brush and bar burning.

Figure 4 — This tension mechanism is specially designed for use on grooved rings.

SEATING BRUSHES

In the matter of brush seating, the author differs from the textbook and the brush and machine manufacturers' instructions, where much space is given to the importance of sanding-in to a 100 per cent contact surface. The reasons given for sanding-in are: (a) that the brush will have 100 per cent contact sooner, and so stabilize the current division and the collector skin in the shortest possible time; (b) that a brush without full seat will not carry its share of current; (c) that current division in unseated brushes is poor; (d) that an unsanded brush placed on an arm in parallel with other brushes will pick copper and break through the collector skin. In the following paragraphs we shall attempt to

show why we must disagree with the above assumptions.

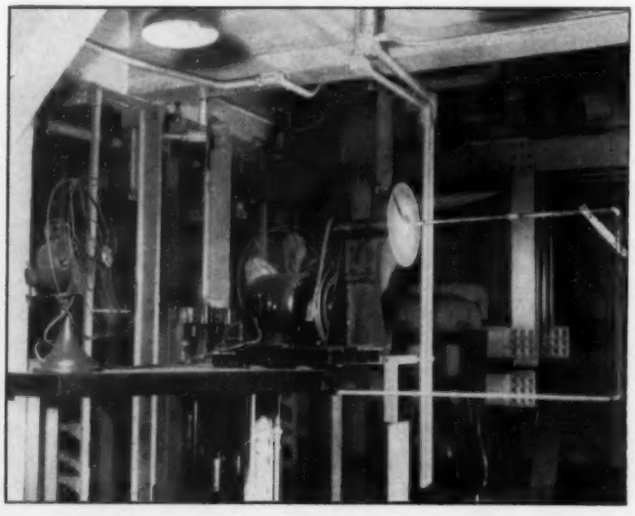
In explanation of the first point (a): whether a brush is carefully sanded-in or not, the first few hours of operation will show about the same amount of working contact. It is desirable however to have the angle as near conformation as possible so that chatter may be prevented.

In answer to the second point (b): that a brush without full seat will not carry its share of current, the reverse of this statement is true. A new brush, even after the most careful sanding-in, will take current from its full seated neighbors. This is due to the contact being made on less than 10 per cent of the surface for the first few hours of wear. Assuming the tension is equal on all brushes, an effective pressure on the current collecting portion of the new brush will be 10 times greater than on the other brushes. The arc spot on the brush with small surface contact will continue to be larger than the adjacent brushes due to the excessive pressure per square inch. This combination results in lower contact drop and more current in the brush until worn to seat.

Item (c), current division in unsanded brushes is not poor as stated. Tests have been made on ring brushes, with ammeters attached to each brush shunt, with brushes operating in parallel, which show that a new, sanded or unsanded, brush placed on an arm with others, will not only take its share of the load but will for a time, until seated, take more current than the others. In spite of all evidence to the contrary, the notion still persists that moving brush contacts perform as stationary resistances in parallel, and the current is conducted by contact rather than by means of an arc. Ammeter tests have been made on many grades of ring brushes on all types of machines, and the results show that the current always divides among unseated brushes best, that as the brushes wear to face, the division becomes poorer until at full face about 20 per cent carry no load whatever. At no time did an unsanded brush refuse to take a portion of the load.

It is stated that an unsanded brush will pick copper, item (d). Any brush, sanded or unsanded, when placed on a high-current, high-speed commutator in paralle with other seated brushes, will pick copper. Any sanding-in to provide a more perfect face only seems to aggravate the situation, for after sanding, regardless of the care exercised, there are always some sand particles left to cut into the commutator skin to start further streaking and copper picking.

Figure 5 — This humidifier has a 10 in. disc operated at 6000 rpm and driven by a ¾ hp motor.



BRUSH REPLACEMENT PROCEDURE

As a practical application of the preceding discussion, experience has proved the following to be the most reliable method for brush replacement on large machines. When it is necessary to install an entire new set, the brushes are sanded to an approximate fit on a beveling machine, and the collector is ground or sanded to provide a raw surface for the new brushes. After the brushes are in place, the machine is put into service and at once operated on at least 25 per cent load. Although machine manufacturers recommend that brushes be "run in" at no load, on high speed applications due to the raw surface and the absence of an ionized film (produced by current) under the brush, rapid wear, cutting, and streaking of the collector are apt to follow.

When the brushes wear down to a point where replacements are necessary, all brushes on one arm are removed and replaced with new brushes without being sanded-in. As other short brushes on other arms require replacement, the longer ones salvaged from the replaced arms, satisfactory for additional wear, are used. These, of course, are already surfaced-in and do not require sanding. By this method it will be seen that when new brushes are added, every path across the commutator is subjected to the same action. Each brush will then react about the same; if there is a disposition to pick copper, all brushes on the arm will do so. The final effect with this arrangement will not be to break through the collector film at a single point causing copper dragging and its attendant ills. The result is to produce a lighter collector film distributed evenly over the surface. This seems to be caused by slight copper picking of all the new brushes on the arm. This condition is to be expected, because of the lower contact drop of new brushes, producing overloads at the relatively small contact areas.

TIME FOR REPAIRS

The time when repairs are necessary is always a question in the mind of anyone responsible for the maintenance of commutating equipment. There should be only two reasons why repairs should be made: (1) to eliminate the hazard of interruptions due to the failure of any part; (2) as an expedient of economy, that the repairs made will result in an over-all saving. There is often a desire on the part of operators to make a commutator or ring "look pretty," that the color or polish should conform to some preconceived notion of the color assigned to well-maintained equipment. Maintenance to obtain these ends can only be justified if the

results will bring about an over-all economy in operation.

It should be borne in mind that the remarks to follow are of a general nature, and will not necessarily apply in some specific cases.

Commutators should be ground either because of roughness (the brushes will indicate this by regularly spaced bumps while the machine is in motion) or in connection with undercutting. In the latter case the grinding is done to remove the axial waves or ridges on the commutator, necessary for the proper operation of the undercutting tool.

The following can be taken as an indication of some of the points at which a commutator should be ground: (a) when the toes of the brushes show chipping, (b) the tops of the brushes (the saddle), where the spring or pressure finger rests, wear, (c) where individual bars show small pits being burned away (this is not to be confused with black bars), (d) where brushes show side wear. This is the wear on the side of the brush caused by friction against spring tension.

Commutators should be chamfered to remove and prevent copper dragging, Figure 1, and to remove any mica fins that may have been left along the side of the slot by imperfect undercutting. This may have to be done between grindings because, as the commutator is worn down, the bevel at the corner of the bar will be worn away. When the bevel is lost, close examination will often reveal thin mica fins lying here and there along the sides of the bars. The presence of copper foil is readily detected both by flashes on the commutator, and pin-sparking originating about 1½ inches from the leaving edge of the brushes, and by observation of strings of copper foil lying in the slots.

Undercutting has become necessary when the mica edges come so close to the surface that further chamfering becomes impractical or impossible. At times, the mica at some points on the commutator will be flush with the bars. After undercutting the bars should always be chamfered.

The warning signal given by slip rings when grinding is necessary is not as obvious as those on commutators. The indications of when grinding is required are (a) vibration of the brushes in the holders sufficient to be audible at a distance of a few feet, (b) sparking on brushes nearest the point on sickle where the bus bars are connected (unlike commutator brushes, any sparking on ring brushes indicates maladjustment of some sort), (c) side wear near the contact end of the brush, (d) broken wire strands in the shunt cable, and (e) the threading (or grooving) reaches a point where the life of the brushes starts to decrease. The need for grinding is to free the ring from flats and eccentricity and to grind out the grooves left by the abrasive in the brushes. On some rings serious flats will develop at a rapid rate, while others will require months to reach a point where grinding is necessary.

MODERN METHODS

Following the introduction of higher speed and heavier current machines, changes in practices and methods have been introduced to cope with the many problems resulting from change in machine design. A discussion of these problems with some attempt at their solution follows.

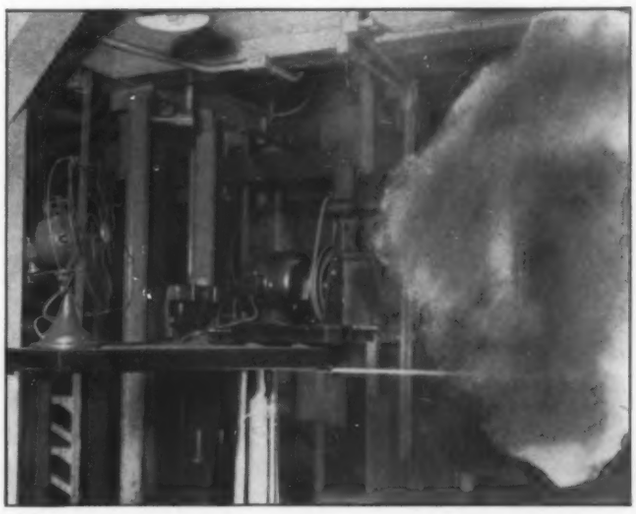
GROOVED RINGS AND COMMUTATORS

Selective action on ring brushes has always been destructive and more difficult to control than on commutators. This is due to: (a) the over-all lower resistance of the circuit, (b) the uninterrupted smooth surface of the ring, and (c) the relatively larger brush sizes used on rings. Should any of the above conditions be upset, logically current division should be improved. To satisfy the first consideration, experiments have been made with brushes having german silver shunts in order to introduce resistance into the circuit. This limited the current a selecting brush may carry. There is still more regulatory action in the increase in resistance due to heat in the selecting shunt. This method, while it improved current division, also increased the grinding necessary to properly maintain the rings. The cause of this could be that at times some of the brushes were "forced" to carry current before the ionized area at the contact was properly prepared to do so.

The uninterrupted smooth surface of the ring may be changed by cutting helical grooves or threads in the face of the ring. The most practical dimensions seem to be about ⅛ inch × ⅛ inch at ½ inch pitch. Relative to the third condition, smaller brush sizes can be accomplished in effect by slotting the brush face with two saw cuts parallel to the armature shaft. Although this will accomplish the same end as grooving, it is of less practical value, principally because the brushes are weakened due to the slots. This practice is often followed by a "tuning fork effect" caused by the vibration of the two sides of the split brush. Thus a high frequency chatter or squeal is set up, becoming higher in pitch as the brush length is reduced by wear. Chatter and broken brushes are also often the result.

With ammeters connected to each shunt on a ring, it was found that on all normal rings about 20 per cent of the brushes would carry no load and another 20 per

Figure 6 — Showing humidifier of Figure 5 in operation.



cent would have 100 to 300 per cent continuous load. The remaining brushes would swing from zero to 200 per cent load. This condition was not present on newly installed brushes, but only after they had been run to face. Good division of current can always be accomplished by slotting the brush faces or grooving the ring surface. After grooving rings, the brush pressure can be decreased without selective action following. For example, before grooving, tension was 8 lb per brush; after grooving the pressure could be reduced with the best results to 5 lb per brush. On all grooved rings it seems the tension can be reduced to about this ratio. Although there are many advantages to the lighter tension, one disadvantage is that the maintenance of the proper pressure is more critical and more care is required of the attendant.

The theory that seems to best explain the cause for the behavior of the altered ring or brush surfaces follows: The ionized spot, or spots, through which the current is carried tends to be cumulative in that once the contact arc has been established, the heat generated by it will ionize material surrounding it. This will produce a larger ionized spot which will lower the contact drop of the brush, causing more current to flow; more heat is generated, enlarging still further the ionized contact. Selective action then results. The fact that the contact drop of a brush, operating on a smooth surface, will be lowered as the current through it is increased, is the basic reason for all selective action. The lowering of the contact drop, due to current, is at last compensated for by the resistance of the brush shunt. This is demonstrated by increasing the size of the shunts and observing increased selective action. Experiments made with brush slotting showed that two slots across the face, parallel to the armature shaft, on a 1½ inch × 1½ inch brush, were ideal. Slots cut with the way of rotation did not change conditions. These facts seem to indicate that current accumulation on one brush is avoided by keeping the size of the ionized spots small. As these spots are formed, they must move across the brush face in direction of rotation. The cuts across the brush face stop further enlargement of the spot, for when a slot is reached, the contact arc will be extinguished. A new spot must be started that in turn will be extinguished on reaching another slot or the edge of the brush. This accounts for the inability of the slots in the direction of rotation to improve distribution. In the case of grooved rings, the grooves pass across the brush face extinguishing the arcs before they have time to reach large proportions.

The present information indicates that it will be profitable to groove the higher speed slip rings. The expense involved in grooving large commutators does not seem to be justified in practice. The grooving of small commutators, where little or no expense is involved, may show some economy.

CLEANER BRUSHES

When it became apparent that the commutator skin was a major factor in the successful operation of high speed machines, the control of this became a problem for consideration. It is the function of skin control that cleaner brushes are called upon to perform. When electrographitic material is used, the following series of events are likely to happen. The negative brushes will continue to deposit brush material on the commutator; the positive brushes lacking in abrasive qualities are unable to remove this film; as this skin increases in thickness the contact drop becomes so high the arcing spots in the brush face tend to become localized until a break is made in the skin, forming a streak around the commutator. At this point, the contact drop is much lower than at other points across the commutator; all brushes on this streak will then pick copper and cut into the commutator. To hold this accumulation of skin in check, cleaner brushes are added. Cleaner brushes must be installed on a whole arm at a time, so the same number will cover each path on the commutator. In choosing a satisfactory cleaner brush grade, it is important that the friction coefficient should be low as well as the material abrasive. The contact drop of the cleaner must be as high or higher than the brushes with which it is to be used. Should the contact drop of the cleaner be low, the shunts will burn as soon as placed in parallel with higher drop brushes. Graphite cleaner brushes when used in conjunction with carbon or electrographitic grades must be used on the negative arms. This is necessary because all graphite material has about 50 per cent greater contact drop when used on the negative side of a generator. The condition is reversed when used on a motor, due to the current flowing through the brushes in the opposite direction. Most commutators can be cleaned with only one row of cleaning brushes. However, some cases will require two or possibly three arms.

CHALK STONE

This commutator dresser is made up of a soft chalk-like material so that when applied to a collector the skin only is removed. This material must be used with the brushes on the commutator, for most of its usefulness is accomplished as the minute particles worn from the block roll between the brush contacts. When it is necessary to remove or equalize the skin or to prevent brush chatter due to a high friction commutator film, the chalk stone is recommended. Whenever practical, the collector skin should be regulated by cleaner brushes and chalking should be done only when this method is unsuccessful.

HUMIDITY

The friction of all brushes is many times increased when the humidity of the surrounding air reaches a low level. This condition is not confined to the brush field, but has been noted in connection with graphite bearings used in the automotive industry. To say, as some texts do, that brushes are of shorter life during low humidity, is not entirely correct. There would be much more truth in the statement that at some low point of humidity there is a place where there will be no brush life. Tests indicate that brush trouble due to lack of humidity is of an explosive nature. As the humidity of the air is decreased, brush life and operation are about the same until a low critical point is reached somewhere

near 1 grain of water per cubic foot of air. At this critical point, friction increases to many times normal amounting to seizure of the metal at point of contact. The heat produced by the excessive friction breaks down the binder and brushes dust away in a matter of minutes. This condition does not take place on peripheral speeds much below 3000 feet per minute, therefore it is not necessary to humidify where speeds are below this point. For safe operation, experience has shown that on high-speed machines the humidity should not be allowed to drop below about 1.25 grain of water per cubic foot of air. All types of brushes are affected, more or less, by the absence of humidity, however, the effect on the copper graphite grades is more explosive and the results more disastrous.

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DISCUSSION

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E. L. Anderson: I know the comments on the effect of humidity are correct. I have not had any experience with this condition on rotary converters, but have had considerable trouble on a 40,000 ampere homopolar generator. Under low humidity conditions, a set of brushes would disintegrate in a very short time. Steam was admitted to the air intake and a moisture content of 1.25 grains per cubic foot was obtained. This was gradually increased until a value of 3 grains per cubic foot was reached. The latter value gave the best operation. Below this value, voltage drop between the brush and the ring and the ring temperatures tend to rise, which is a forerunner of trouble. During the period steam was used, the value of humidity was taken every hour and necessary adjustments made.

About two years ago, a water-washed air system was installed. This has given excellent results and it has been possible to eliminate hourly checks on the moisture content of the air. There is no question but that the control of humidity has a direct bearing on brush life.

M. S. May: Mr. Cook mentioned the chocolate brown commutators that we once thought were so necessary. In more recent years, some of us, at least, have concluded that the chocolate brown color is very fine on certain machines, but that the color of the commutator is largely a function of the machine characteristics; in other words, that certain machines will give optimum results with the chocolate brown color; certain machines will give optimum results with a light brown color or almost yellow color; other machines give best results with an almost jet black commutator color. It appears to me that what we should strive for is a film and a color that is stable, that does not vary. Having that, we very frequently have the best we can do on that individual machine. Our experience seems to confirm what Mr. Cook has said about the necessity for brushes that clean or have abrasive action, and we find that very often it is the only way to offset difficulties and to solve certain problems on machines.

On the contrary, however, in some instances we have been able to correct the condition without going to an abrasive brush. That is usually accomplished by putting on a brush that is perhaps lower in friction and better in commutating characteristics than what have been used before. In other words, if we can perhaps reduce the localized temperature, or perhaps I should state it in a different way, the temperature of the localized hot spots on the commutator, we tend to retard the build-up of too much film and get somewhat the effect of an abrasive action without really having an abrasive action at all.

In some instances, rotaries that have shown the bar marking on every second or every third bar have been corrected by either of the two methods, either by using the addition of abrasive brushes or by using a non-abrasive brush somewhat higher in contact resistance

and somewhat lower in friction than those previously used.

For perhaps the same reason, the use of smaller brushes or, as we have sometimes done, the use of split brushes, has given a somewhat similar effect. The smaller brush or the greater number of brushes, or greater number of contacts, tends to reduce the localized hot spot temperature, to maintain better contact with the commutator, and therefore gives you a cleaner commutator and a less heavy film, even though you have not actually added any abrasive material whatever.

On the proposition of contact with newly-installed brushes, I have felt that it is more important to try to get good contact circumferentially than axially. In other words, to get contact with the brush around the commutator as far as possible, even though it is only a line contact, for the reason that if the contact is not in that direction you may have the effect of shifting brushes and tend to upset your commutation characteristics.

It is true that you seldom, if ever, get anything like a hundred per cent contact until the brushes have been on for some time.

There is one question which I would like to ask regarding the comments on the lack of current distribution among slip ring brushes. Mr. Cook pointed out the fact that some carry no load, some carry several times as much load as you anticipate, and some are in between. I wonder whether Mr. Cook observed any relationship between the load in the brushes and the position of the brushes on the yoke, with regard to the point where the current leads are brought in. In other words, where the leads may come in at the bottom, is it the brushes toward the bottom that tend to carry the most current and the ones toward the top that tend to carry the least?

L. D. Cook: Yes, we have noticed that. There is more current near the point where the leads are connected. Current in relation to the bus connection always form about the same pattern. We have never found this pattern to be the result of brush tension differences.

We have kept the tension just as even as we could and taken tensions and plotted them with the amount of current in the brushes. Believe it or not, sometimes the 300 per cent overloaders have the least tension of any brushes on the ring.

Park D. Manbeck: In regard to the porous or open-grained brushes which Mr. Cook stated formed the heavier films, I suppose that electrographitic brushes were referred to in this case, and not necessarily graphite brushes, because natural graphite brushes may lay down a much lighter film than the electrographitics though they are quite porous.

In regard to the negative brushes rebuilding the damaged film, I assume that Mr. Cook meant negative in the generative sense, not in the motor sense.

It has been our experience that it is the cathode brush, or positive brush on the generator, which lays down the film, since it is the cathode brush where the oxygen is liberated in the electrolysis of the moisture layer.

In regard to brush angles, I would like to make a comment that an angle of fifteen degrees is best where loads vary quite widely, or where low average operating current density is encountered because of the danger of the brush chattering at low loads. I think you probably noticed that on nearly all railway commutators the brushes operate at fifteen degrees.

With regard to sanding brushes to face, I think there is no conflict of opinion on the question of brush seating practice. Mr. Cook's proposal of installing brushes without sanding is quite satisfactory, I think, where it is not necessary to make accurate generator voltage tests or motor speed regulation tests, such as the manufacturer has to make on his bench test of new apparatus.

We would much prefer that the brushes be loaded somewhat as soon as they are installed. That is to aid in building up the film. If there is no current through the brushes, there is no electrolysis of the moisture layer, and there can be little or no film laid down, and the brushes might start to cut the commutator before the film is laid down and destroy the smooth surface which you have taken so much time to establish in your reconditioning of the commutator.

Donald R. Wilcox: Mr. Manbeck brought up the subject of which brushes pick copper and which ones lay down the film. I had assumed that everyone agreed that the negative brush in the generator sense laid down the film and the positive brush picked the copper. I think we can have some comments from people who have had a lot of good experience on homopolars and on the low voltage sets, where that point would be brought out.

The point that Mr. Cook brought up in his paper about graphite brushes, particularly cleaner brushes having greater drop, is interesting. The lower drop is on the positive arm in the generator sense, whereas the negative brush has the higher drop. It is our feeling that it is an electrolytic action or, as Mr. Cook says, an arc, which permits the deposition of graphite on the commutator under the negative brush in the generator and picks copper, or tends to pick copper, on the positive brush. That makes the positive graphite brush, which is a soft material and which holds these little particles of copper, actually a copper graphite brush which has a low drop.

In contrast to Mr. Cook's observation, we seldom recommend and seldom use cleaner brushes, but when we do, we put them on the negative arms, and our observations have been that changing them to the positive arms causes greater cleaning action. An example is a rotary where we had a great deal of difficulty. The film was heavy, commutator temperature was high and there was selective action and sparking.

We first recommended an increase in pressure. It was from 1½ to 2½ psi. I think we could have gone higher. That helped the situation, but it didn't clear it up. Then we decided to put cleaner brushes on the negative arm. The cleaner brushes helped the situation some, also; but when we changed them to the positive arm, that cleared up the situation. It was a cooler commutator, and sparking and selective action were eliminated.

L. D. Cook: I must say the answer to that one is "yes" and "no". I think that it's all right to put cleaner brushes on the positive, if you can get away with it, but the only trouble is that if they are put on the positive arms with electrographitics they tend to overload and burn the shunts.

E. L. Anderson: I feel that homopolar generators

are in a class by themselves and do not belong in this discussion. The rings on a homopolar generator operate continuously at a fixed polarity and therefore current flow is in the same direction at all times. This gives a cathodic action on one ring, and an anodic action on the other. Theoretically it is good practice to put a brush having a high content of cleaning agent on the negative ring and one without or with very little cleaning agent on the positive ring. In practice, however, it is not economical to maintain two grades of brushes, and satisfactory operation has been obtained by a single grade of brush on both rings, using a compromising amount of cleaning agent.

H. R. Partridge: Mr. Cook and his company have made an outstanding contribution to the practical business of operating brush using machines, and in developing the system of humidification which he describes. There is no doubt that brushes do wear more rapidly as the air becomes drier after a certain low point.

I am inclined to take issue with Mr. Cook when he says in his informal remarks here that practice should catch up with theory. In my opinion the theory on carbon brushes is in the elementary stage and practice is way out in front. It is very much the same for brushes as it is in the case of steel. You men are making better and better steel all of the time, and your scientists and technicians are constantly at work in evaluating your products. That is just about the situation regarding brushes.

The brush industry is making brushes better and better every year. Every company is improving its products, and the technicians are kept very busy trying to make the theories fit, and that gives us all a lot of pleasure.

Mr. May mentioned a so-called multi-flex brush, by which he means that you take a brush from a single holder and divide it into two parts and put the two parts side by side in one holder. That has been done for a good many years and does have certain advantages, because, as he rightly said, it reduces the size of the brush; in other words, it reduces the inertia of the brush. If we had machines fitted with a large number of very small brushes, we would have a lot less brush trouble on the whole, but that is not a practical proposition. So some of our troubles in operating brushes are due entirely to the size of the machines and the large size of the brushes themselves. I think that all of the brush companies are paying a lot of attention to that problem. They describe it in different terms but it boils down to the problem of getting brushes to ride better and better.

Mr. Cook discusses the question of cleaner brushes. The use of cleaners very often improves the riding properties of the brushes, and sometimes we think we are doing one thing, when actually we are succeeding in doing something else. There again, what does it matter as long as you improve your machine performance and reduce your operating expenses?

As far as this argument of Dr. Manbeck goes about positive and negatives I do not propose to get into that at all. There seems to be some basis in what he says judging from results we see in laboratory work, but generally speaking in practice we put cleaners on the negative arms of the machine, if it be a generator.

The control of the film is really one of the big problems in brush operation. He is quite right, in my opinion, when he says that the film will continue to grow and grow unless it is controlled; and we have all seen brushes break through film and witnessed the consequences, which are bad. So it seems true that we are all up against the problem of film control and there again I think practice is way out in front of theory. You have to have a film but it has to be right. When our company brought out cleaners twenty-five years ago it did not call them cleaners. We wanted to be different, so we called them "stabilizers" with the idea of getting across the thought that we were really trying to stabilize the film when using a cleaner brush. If you can stabilize the film and keep the brushes riding properly, then you are very well on the way to having economical brush operation.

Carl C. Sittler: Mr. Cook was given the responsibility for the operation of large, high speed, 60-cycle machines in the days when most men still believed, or seemed to believe, that the office boy could design brush holders and an apprentice could handle brushes. The practices he outlines in his paper are the result of many sleepless nights during which he went from the extremes of high spring pressures to hold the brushes down to the latest idea of helical grooves and light pressures.

It is interesting to me, and perhaps to others, particularly brush men, that Mr. Cook does not once mention low operating temperature as a requirement or even a factor in good brush operation. We must have temperature limits, but we can never agree with a man who selects a brush grade as superior because it operates at five degrees lower temperature. I should like Mr. Cook's ideas on this matter. In his paper, Mr. Cook went into copper dragging at considerable length. He mentions a number of preventives for copper dragging, most of which are adjustments for better mechanical conditions. Some are for improvement of commutation. We find that poor commutation is frequently an unsuspected cause of this difficulty. For example, we were called in to help eliminate copper dragging on a 600-volt rotary in an unattended railway station. The question was, why did this grade of brush operate satisfactorily for years and now give us trouble. The answer was, changing load conditions caused the rotary to operate at poor power factor, with the resultant poor commutation, not bad enough to cause noticeable sparking and make the remedy obvious, but bad enough to cause copper dragging. Field adjustment eliminated the trouble. Therefore, we always suggest a search for poor commutation when slots are being bridged by copper dragging.

L. D. Cook: We used to pay quite a lot of attention to temperatures, but it seems to me that when we correct these other factors the temperature will more or less take care of itself.

There are many test data and recommendations on temperatures, but, for one thing, it is difficult to get actual temperatures. I think that in many cases they are irrelevant unless obviously excessively high.

Hugh Wikle: I do agree that carbon brushes should be sanded, but not if I have to do the sanding. I have spent too many years of my life sanding in brushes to relish the idea. However, I think that for most operators it is good practice to have them sand the brushes

because there is still too much carelessness in the handling of carbon brushes and in their installation. Too often operators mix two or more grades on the same machine, and too often they pay too little attention to spring tension and brush alignment.

Recently, I ran across an electrician who was very religiously cutting off the pigtails before installing them. So, I would say, as a general rule, if it were not for any other reason than good workmanship, to have them at least partially sanded in.

The only one that I ever knew of who had perfect commutation with carbon brushes was a fellow townsman of Mr. Cook's, an electrician who operated an elevator in one of the Loop buildings. He had considerable brush trouble on an old-type motor, so he decided that the brush manufacturers didn't know anything about carbon brushes and he would make his own. He proceeded to make up one carbon brush and put on the pigtails. He tried but one, and the commutation was absolutely sparkless, so he thought he had his brush problem solved, and spent a Saturday and Sunday making up a whole set of brushes. He put them on, and the commutation was absolutely sparkless. The only trouble was that the motor wouldn't run; he had made them out of black fiber.

I think we can get a better idea of the film formation if we think of it not as a solid, but as being in a fluid condition, something like a stream of water flowing underneath the brushes. This film, of course, is made up of copper oxide, a little grease, a little dirt, some graphite and an air film, a little bit of everything, much as a muddy stream would be flowing down toward the sea.

This film changes with every change in temperature, humidity and load condition. There are so many factors to be considered that it is hard to picture this film as an exact condition. It is a variable condition. After the brushes have been in operation for some time, this film does reach a more or less constant value, and will remain so until the operating conditions are changed.

C. Lynn: The film surface on the commutator has a large bearing on the operation of a machine. I agree with the statements previously made about cleaner brushes, except that in the years past, we recommended that they be put on the negative arms of generator and the positive arms of a motor. However, in the last few years, we have applied them to both the negative and positive arms equally divided on both motors and generators, with very good success. By doing this you have only half as many cleaner brushes per arm and, therefore, you do not get great inequalities in current division between the cleaner brushes and regular brushes on a given arm.

Speaking of the division of current between different brushes on the arm, I would like to mention some tests that we made quite a few years ago on collector rings, in order to secure more equal division of current among the various brushes on a given ring. We made a common core transformer for the alternating current, which was fed into one of the rings on the a-c end of the synchronous converter and fed each brush through a winding on one leg of this transformer. The construction of the transformer was such that with a common core, each individual winding connected to an individual brush had essentially the same current. The results of this test were bad. When a brush does not want to carry any current for the time being, it really means it does not want to and should not be made to do that. Eventually it will carry its share of the current.

We made measurements once to determine the gaseous pressure under copper graphite brushes operating on a collector ring on a synchronous converter. The brushes used were 1½ in. square, and we measured the pressure by drilling a hole radially through the brush and inserting a rubber tube in the hole and connecting it to a manometer. Three or four inches of water pressure was measured, which corresponds to about one-tenth of a pound of gaseous pressure. With slots in the brush or grooves in the ring, you relieve that gaseous pressure and, therefore, have more intimate contact between the brush and the ring.

I think spiral grooving was first brought out in the early "20's" by Dr. Little of our research department. One of the main advantages of spiral grooving of the collector ring over slotting of the brushes is that it makes every spot of the brush during one revolution of the ring have no contact with the ring. Therefore, each spot of the brush must at one time per revolution, give up its current and thus the current is redistributed over the surface of the brush. Additional cooling can also be secured by grooving because this adds additional area on the exterior surface of the ring.

As far as grooving of commutators is concerned, there is not the necessity, as Mr. Cook pointed out, that there is on grooving collector rings. The undercutting between the commutator bars provides a relief for the gaseous pressure under the brush on the commutator surface. This also causes continuous redistribution of the current over the contact face of the brush, since there is no area of copper in contact with the brush in the undercut area.

We have found that if commutators are not mechanically stable, that is, if they will not go through a temperature cycle and stay smooth, spiral grooving will help the operation. If the commutator is stable from a temperature standpoint, one that is thoroughly seasoned, and will go through temperature cycles, then we have found no advantage in spiral grooving except the temperature rise of the commutator might be reduced a very few degrees. By a few degrees, I mean less than five. The question of the temperature of the commutator is particularly important with a commutator that is not mechanically stable. Lowering the temperature will give improved operation if the commutator borders on instability from the standpoint of temperature. There is, of course, a definite upper limit to commutator temperature operation, because as the temperature increases the roughness of the commutator also increases.

Brush holders are very important in this question of current collection. So far, no one has mentioned the double brush holders which have been used by the large electrical manufacturers on their larger sizes of machines. We think that the double brush holder has a lot of merit. The operators sometimes do not favor them because it is a little more difficult to change brushes. However, the superior performance that can be secured by using double brush holders, warrants their use. In this connection I would like to distinguish

between the double brush holder and a split brush. In a double brush holder you have two separate brushes with a divided partition in the brush holder separating the two. One brush trails the other. There are several reasons for the improved operation when using double brush holders. One reason is a mechanical one and that is, that the inertia of the brush is cut to half, which means that the brush can more readily follow minute irregularities of the commutator surface. Another reason is that whenever a high bar comes under a double brush holder it will only lift half of the brush off of the commutator at one time, which, of course, would not be so in the case of a solid brush. There is also an electrical reason for improved operation, and that is due to the additional resistance to circulating currents in the coil being commutated. In this case the circulating current has not only the contact resistance, but twice the resistance of the full length of the brush since the current has to travel up through one brush, through its shunt and back down through the shunt and brush body of the other brush in the double brush holder.

When split brushes are used, pressure is applied to both of the split brushes by one spring bearing on a top clip which is riveted to one of the split brushes only. If a high bar comes under that half of the split brush to which the clip is not fastened, it will lift both of the split brushes off the commutator, acting exactly like a solid brush. When the high bar comes under the brush to which the clip is attached, it lifts that brush off the commutator and the other brush is then free to fall back on the commutator without any pressure being exerted upon it from the pressure finger or clip of the other brush. In talking of these high bars we are talking microscopic dimensions or in fractions of a thousandth of an inch. However, split brushes are an improvement over solid brushes, and in my opinion give about half the improvement of a double brush holder over a solid brush.

This paper of Mr. Cook's has been limited primarily to brushes, but the development of commutators by the large manufacturers over the past ten or fifteen years, has helped a lot in the reduction of maintenance in the current collection problem. Also the development of brushes by the brush manufacturers has kept pace with the development of commutators. Every time an improvement is made in commutator operation or in brush performance, the electrical machine manufacturer immediately takes advantage of it in building larger machines, machines at higher speeds or with higher speed ranges, or in loading the commutator heavier if possible, in order to give you steel men motors with which you can roll steel at greater rates.

S. S. Callner: I was very much interested in Mr. Cook's references on maintenance of commutators with reference to undercutting of mica. There seems to be a great deal of controversy as to whether the "U" type or the "V" type is more desirable for undercutting. I wish to mention some observations I have made. The main advantage of the "V" type saw or milling cutter is the fact that it is only necessary to carry in stock one thickness whereas with the "U" type, it is necessary to carry many thicknesses for the many variations you find in the commutators. The advantage of the "V" type is in the belief that an operator can remove the mica and chamfer the bars at the same time, whereas with the "U" type, it is necessary to chamfer the bar with a hand tool afterward, making two operations.

However, in field maintenance it is necessary to use portable equipment, which at its best is very awkward and inconvenient. My observation is that by using the "V" type milling cutter, the results are not consistent. It is too difficult to get the milling cutter deep enough, and as a result, no copper is removed from the corners and sufficient mica is not removed. In no time, mica fins appear on the side again and you have trouble. As a matter of fact, Mr. Cook recommends chamfering of bars after undercutting regardless of whether a "U" type or "V" type is used. Therefore, we cannot observe any advantage of the "V" cutter on the basis of time saved in field maintenance. In the repair shop, where the armature has been removed from the housing, it is possible to accomplish good results with the "V" type. The operator is not subject to the same conditions as you find in field maintenance. Further, it has been my observation that the majority of equipment manufacturers use the "U" type on new equipment, followed by chamfering. My opinion, therefore, is that for field maintenance, the best results are obtained by using a "U" saw so that there is no doubt about the mica being removed, then chamfer afterwards. In the repair shop, the "V" type may be used. A well done undercutting job will prolong periods between general overhaul and breakdown of equipment.

C. E. Homer: As far as brush applic. tion and commutation are concerned, I think too much has been done in the past by the old cut-and-try method and not enough study and thought and careful analysis given to the problem of selecting the proper grade and getting the correct commutation on the machine.

We all recognize, of course, that every machine in the steel plant, or anywhere else as far as that goes, is an individual problem and that there is no rule of thumb or "Page 9" of a certain book that will take you to the answer of what brush to put on any machine. In fact, we have all had the experience of having two similar machines in the same room requiring two different kinds of brushes.

I think one of the most serious problems we have in the steel industry, as far as brush application is concerned, is the widely-swinging loads. Practically every steel mill generator swings from no load to full load, twenty-four hours a day. Of course, that does present very serious problems to get a brush that will commutate successfully under those conditions.

On the question of eliminating sanding of new brushes, I am sure this is something that we are all in favor of, if practical. However, personally I am not quite ready at the present time to accept this practice, as I am still of the opinion that to give a new set of brushes a fair start, they should have a relatively good fit on the commutator. However, I appreciate that in some instances in our own plant where this sanding-in has had to be rather hurried due to lack of sufficient time, and we have not done as good a sanding-in job as we thought necessary, we have not noticed any ill effects on the commutator or commutation.

James H. Miller: I will discuss two points wherein there is a little divergence of opinion from the practice that Mr. Cook outlined and which have proven satisfactory. In a steel mill we are confronted with so many

auxiliary drives that are d-c, my discussion will concern both auxiliary drives and main drive motors and generators.

During recent years we have operated motors on duplex drives, one of them chamfered and the other not chamfered, that is, beveled. I used to be one of the fellows who insisted on beveling bars. The test that I am speaking of in particular was started in 1940, and today neither commutator has been out of service at all; it is hard to notice any difference in the surface. The commutation on both motors is satisfactory. I believe that the main reason for chamfering is the result of poor undercutting, as somebody else has mentioned here, and portable tools have a large responsibility for this. By chamfering you are more certain that the mica is removed.

I am opposed to the use of cleaner brushes and would use them only as a last resort. With the wide variety of brushes available today, and careful observation when they are installed, surely a brush of the proper grade may be found which will do the job. This will eliminate the necessity of cleaner brushes and their exacting application. So I step out of the picture as to whether you want negative or positive arm installation with cleaner brushes. It has been my experience, also, that machines requiring cleaners or even the consideration of cleaners are in the minority.

Mr. Cook's remarks covering sanding-in were particularly interesting. It is doubtful to me that many of our auxiliary drive brushes in the steel mill ever got a good sanding-in. I think where you have a motor down under a table in a hot spot, the motor inspector does not stay in there any longer than he must. The trouble which might be expected from not sanding properly was explained by Mr. Cook.

We have all had several definite ideas about this problem. One of them that we have seen often, for example, is "Do not use oil on the commutator," yet I have seen machines where oil was applied regularly and with good results. If each problem of brush operation is approached by careful investigation, unfettered by such rules — in other words, with an open mind — I am sure the answer will be forthcoming.

L. D. Cook: I do not think we are so far off as might seem, because I agree that chamfering is simply the result of poor undercutting. The same thing is true with cleaners. I said in my talk that I hate to recommend them because they are a bother and should not be used if you can get away with it. We have not been able to get away with it. Maybe we can some day.

W. B. Ferguson: I gathered from Mr. Cook's remarks that the present day theory indicates that current is normally carried from commutator to brush or the reverse by a series of arcs existing between the rotating commutator and the brush face. It would seem to me that this arcing is the result of poor commutation rather than a means of commutation. We are all quite familiar with the arcing taking place on machines which are not commutating properly; this does not mean that such a condition is normal.

Mr. Little of the Westinghouse Electric Corporation research laboratory back in 1931 proved that, under an average brush running on an average commutator, only three to seven points of contact exist which normally carry current; these points are varying and shifting continuously, of course. It is quite obvious from the above that current densities would be extremely high at the very few points of contact, resulting in arcing. We must not lose sight of the fact that an average brush can short circuit only two to two-and-a-half volts without excessive local currents running so high that commutation would be impractical.

Commutating pole machines should have sufficient commutating pole strength to always neutralize the short circuit voltage across the brush within a limit represented by the brush contact drop in order to keep such values within the limits of permissible currents. This means that brushes should be kept as narrow as possible, the brush resistance should be kept uniform and as high as practical, and the brush should be set exactly on load neutral.

If a machine, due to inherent design or careless assembly, has a tendency to shift neutral under severely varying load conditions, there is very little the poor brush can do about it.

Brush angles are critical as pointed out by Mr. Cook. I have known of one instance where the brush angle was altered during repairs to a machine to such an extent that the no-load heating on the machine exceeded full load heating.

There are one or two other points I should like to toss on the table with the hope that some time soon some manufacturer will give us a satisfactory answer to them: Why, in view of the fact that copper oxide is the curse of commutation are commutators not made with silver faces, not just plated surfaces nor solid silver bars but probably wearing surfaces of $\frac{1}{16}$ to $\frac{1}{8}$ of an inch in thickness. The silver oxide being as good a conductor as the parent silver should eliminate that phase of commutating trouble. Another thing which has always baffled me is the fact that the brush people spend one-half of their life putting on brushes which will impart a surface to the commutator and the other half putting on cleaner brushes which will cut it off. It seems to me that some happy balance between the negative and positive brushes could be arrived at whereby the proper amount of surface could be maintained at all times.

Then there is the question of flats on collector rings. I believe these are started during periods of primary power application when the field is shorted. The brush imprint is burned on the ring and subsequent running will lift particles of the metal ring on the positive ring only. This condition may be minimized by reversing field polarity every three or four months, but there is one sure cure — helical grooving of the rings.

This raises another point — why then don't we groove commutators? As mentioned briefly by Mr. Cook we do, but I don't believe enough study has been given to the subject as it has great possibilities when we stop to realize that instead of our original three to seven points of contact under our average brush, we get from seventy to one hundred points of contact, a tremendous increase in current carrying capacity. And it actually works that way.

L. D. Cook: One point apparently I didn't quite get over was about the arc carrying the current. I did not mean sparking. The arc has nothing at all to do with sparking, but I was talking about an invisible arc, or at least an arc covered up by the brush.

REVERSING AND TANDEM COLD MILLS

. . . . a comparison of the tandem mill with the reversing mill emphasizes the point that the reversing mill offers lower investment cost and greater flexibility, whereas the tandem mill gives lower operating cost and greater production . . . .

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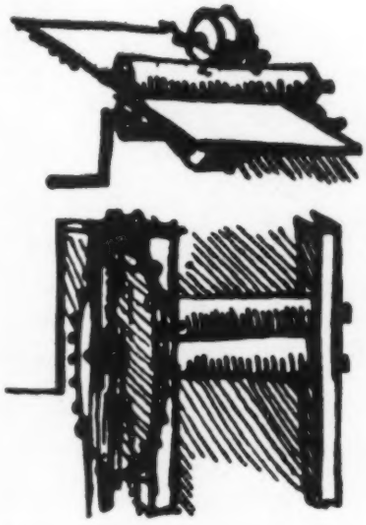


Figure 1 — The first known 4-high mill is shown in sketch drawn by Leonardo da Vinci, and dates back to 1495.

▲ FOR the process known as cold reduction or cold rolling of flat metal, there are two types of mills in general use at present, the 4-high reversing mill and the 4-high tandem mill. There are, of course, other types of mills that are employed for this purpose, but owing to their rather special characteristics and limited use, they will be largely excluded from this present discussion.

The art of cold rolling of metals goes further back in our industrial history than many people realize. In the earliest days, the softer metals such as tin, lead, and zinc were cold worked down by rolling on 2-high mills, but there is on record[1] in the sketches of Leonardo da Vinci, dated 1495, what might be called the first 4-high mill for cold rolling, see Figure 1. The mill resembled a present day clothes wringer in general construction, having two reducing rolls about 2 in. in diameter by 12 in. long, direct connected to a hand crank, and backed up by two shorter rolls, about 2 in. long. Cold rolling of gold and silver coin metal was practiced from 1553 onward, as recorded by one Bruliers, a Frenchman. Flat cold rolling of iron and steel, however, does not seem to have been successfully carried out until some 230 years later, although flat hot rolling of steel on 2-high mills had been known since about 1660. Cold rolling, really only roller polishing, was practiced as early as 1747, in England, on tin plate. It was in 1783 that John Westwood in England proposed cold reducing of steel bands for watch springs. Cold rolling was later developed both abroad and in America, and from 1825 to 1860, due mainly to improvements in the manufacture of rolls, considerable amounts of high carbon flat wire, corset stays, etc., were produced by cold rolling.

The development of flat cold rolling of steel as a production process, however, gained real impetus only after the evolution of the 3-high cold mill, by Bernard Lauth (of England and the United States) in 1864, when he received a patent on the idea of a smaller diameter middle (work) roll. The recognition of this fact, however, should be carried back more than 100 years earlier, to a description of a mill by the Swedish technician, Christopher Pohlem, who died in 1751, and who had previously described a 4-high mill for flat hot rolling, using "slender" wrought iron work rolls, supported by large cast-iron backing rolls, because "small rolls possessed much more power of stretching (elongating) material than did large ones." The commercialization of the Lauth cold mill, however, was carried out principally in America by the old American Iron & Steel Company of Pittsburgh, later acquired by Jones & Laughlin. As the superior properties of cold rolled strip

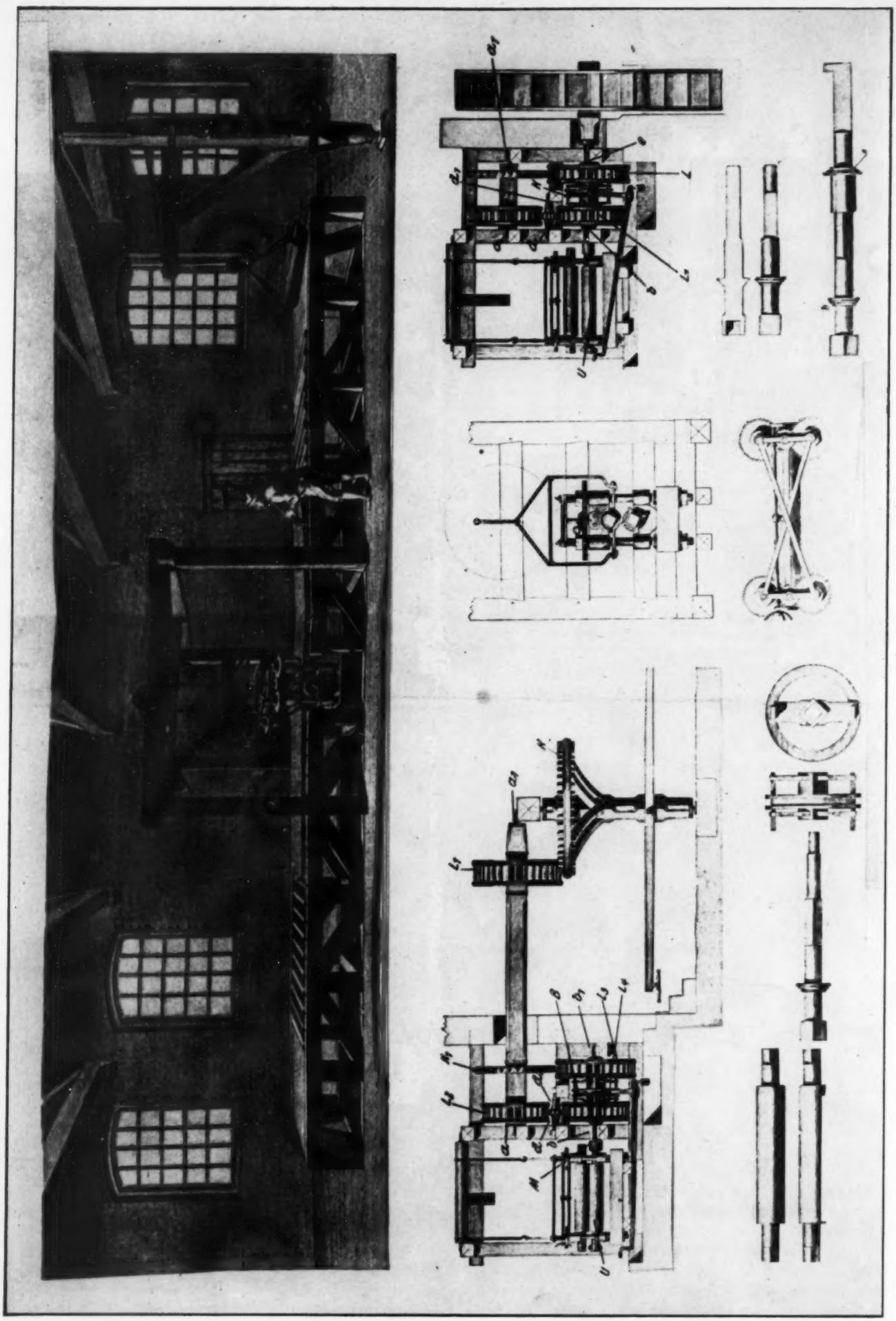


Figure 2 — The first reversing mill in England was designed in 1728 for the rolling of lead sheets.

became more and more appreciated, cold rolling spread even more widely both in this country and abroad, being practiced primarily on 2-high and double 2-high mills, although 4-roll and 6-roll cluster mills on the Wilmot and Mann types were later used in this country. The first 4-high mill for the cold rolling of steel is as recent as 1923, by Allegheny-Ludlum (experimental). Roller bearings on such 4-high mills were first used in 1926 at American Rolling Mill Company, Butler, Pennsylvania, although they were introduced the previous year for the 4-high cold rolling of copper alloy sheets, at the Rome plant of Revere Copper and Brass Company, both being built by our company. Roller bearings on rolling mills in general were first used on the roll necks of 2-high cold mills as early as 1890, in New England, and on the back-up rolls of cluster type cold mills in 1909, on the Keating mills of the American Tube and Stamping Company of Bridgeport, Connecticut.

The urge for ever increasing production, at reduced costs, developed early along two principal lines, the reversing mill, and the tandem mill, although the 3-high mill and the double 2-high (double duo) held sway for some little time.

The earliest record of a reversing mill (other than by manual operation) is credited to England, in a description by a Frenchman, Fayolle, in 1728. This mill, shown in Figure 2, was very nicely worked out, and apparently was contemplated to be driven either by water power, or horsepower. It was for the cold rolling of lead sheets. The reversing gear was of primary importance, and naturally of considerable interest. With the first steam engine driven mill, by John Wilkinson in England in 1781, the difficulties of the reversing gear multiplied. After almost a century, through the joint effort of Messrs. Naysmith and Ramsbottom, the first reversing steam engine driven mill was put into operation in 1863. In the interim, American enterprise, in the person of John Fritz, of the Bethlehem Steel Company of Johnstown, developed the 3-high mill (for rolling rails) in 1857, although it had been proposed somewhat earlier in England. The first reversing 4-high mill of record was used by the old Carnegie Steel Company at its Homestead plant, in 1891, was engine driven for the rolling of slabs(2). With the application of electric power to mill drives, first in Sweden in 1894, using a-c wound rotor induction motors, the reversing-motor mill drive was soon after successfully developed by Carl Ilgner in Germany, using d-c motors, powered by induction motor driven d-c generator flywheel sets, with generator field control (Ward-Leonard system, developed some ten years previously in this country), in 1902. Reversing cold mills with dual tension reels of the 2-high type, were first used in Germany in the 1920's, having been disclosed in the patent literature as early as 1917, and of the 4-high type in 1932. The first such cold mill in this country was installed at Gary in 1933.

Tandem rolling also had early beginnings. The first truly tandem mill, where the material being rolled is in more than one stand at a time, was patented by one Richard Ford, in England, in 1769, for the continuous hot rolling of wire rods. In 1798, John Hazeldine added mechanical guides, as shown in Figure 3. Tandem rolling of hot strip steel took an upsurge around 1890, and in 1892, the Teplitz semi-continuous hot strip mill, with a mechanically geared 2-high tandem finishing train, was built. Our first record of tandem cold rolling of steel strip goes back to about 1904, when the West Leechburg Steel Company installed and operated a 2-high 4-stand tandem mill, each stand being driven by a separate, adjustable speed d-c motor. Real tandem operation, with tension between stands, and a tension reel, was developed around 1915, with the installations of the Superior Steel Company and the Morris & Bailey Steel Company of Pittsburgh, see Figures 4 and 5. And in 1926, the first 4-high tandem cold mill, a 4-stand tandem mill, was put into operation by American Rolling Mill Company at their Butler plant.

In either the tandem or reversing operation of mills, as the strip being handled got longer, and was rolled at higher and higher speeds, the matter of handling the material necessarily demanded attention. This occurred first in the hot rolling of wire rods, and the first reels on record were used around 1860, being manually rotated by a boy, who visually synchronized the reel with the mill, which boy previously to the introduction of reels, used to run with the front end of the rod (and thus determined the delivery speed of the mill). The reels were subsequently mechanized. The cold strip reel seems to have preceded the hot strip reel or coiler by some ten years, the first cold reels being built in Germany by August Schmitz Company, around 1893. The reels were well designed units, having wedge-type collapsing segments, and driven from the mills by slipping belts, for tension control. The first high tension reel, as such, was patented in 1905 by W. F. Conklin, of Pittsburgh, using a slipping friction clutch. Around 1920, the separate electrically driven reel, maintaining constant tension by current control, was developed jointly by the Superior Steel Company and the Westinghouse Electric Corporation.

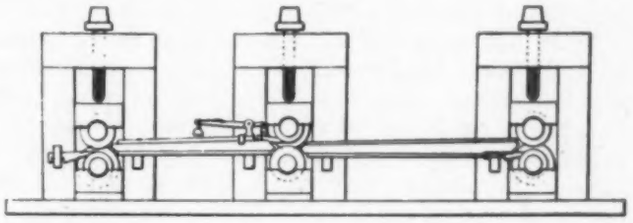


Figure 3 — Guides were used in this early English tandem mill.

The concurrent development of reels and the electric drive resulted in the development of strip tension control, first between mill and reel, and later between stands of the tandem mill. Although the first tandem cold mill was operated with slack strip between stands, the art was later advanced to the using of slack or loop take-ups, and finally to the adoption of high interstand tension around 1920. The role of the electric drive, and electricity in general, cannot be overemphasized as the main contributory factor to the ever increasing speeds and tonnages of modern cold mills, as well as improved quality and control.

In discussing the relative merits of present day tandem and reversing cold mills, we are not attempting

Figure 4 — This is one of the earliest tandem strip mills built in the United States.

to justify one type of mill over the other, or to make comparisons in favor of the tandem mill against the reversing mill, or vice versa, but rather to establish the justification for the selection of one or the other to meet certain requirements. The two types of mills each has its own respective fields of application, which however, at times are overlapping.

Before assigning the mills to their respective fields, let us first consider the essential elements of the modern arrangement of these two types, both of which are designed to receive metal strip in coil form, reduce the thickness or gauge a certain amount imparting certain physical properties to the final product, and deliver the rolled product again in coil form.

The tandem mill comprises two or more roll stands in line, in which the stock to be reduced is passed through in one direction, being reduced in thickness in each successive stand, being in all mills at the same time. On the entry side of the first stand, means are provided for uncoiling and feeding the strip into the first stand. Guides are provided between the stands to feed the strip rapidly and easily from one stand to the next, and from the last stand to the rewinding reel or tension reel. Each mill is driven by a separate d-c motor, as is the reel, all from a Ward-Leonard motor-generator set. Figures 6, 7, 8, and 9 show typical two, three, four, and five stand tandem units.

The reversing mill is a single stand unit, through which the strip is passed back and forth for a number of passes to obtain the required reduction. On one side of the mill, means are provided for uncoiling and feeding the strip through the mill to the tension reel on the other side. After the first pass, the back or tail end of the strip coming from the uncoiler is gripped by the second tension reel on the uncoiler side of the mill. The strip is then rolled in successive passes in alternate directions until the desired reduction is attained. On the last pass, the tail end of the strip is released from the unwinding tension reel, the coil completely wound on the winding reel, and stripped therefrom, just as in the case of the tension reel in the tandem mill. Figure 10 illustrates such a reversing mill, with collapsible tension reels, while Figure 11 shows a unit employing solid reels. For this latter unit, the raw coils are wound onto the solid reel or drum as a separate operation, or may be fed initially from an uncoiler, as in the case where collapsible reels are employed.

The tandem mill has generally been classed as a high production single purpose unit, while the reversing mill has been considered adaptable to a relatively moderate production of one or more types of product, or specialties. The tandem mill stresses production and the reversing mill flexibility. However, the two types must not necessarily be confined to their respective fields of production and flexibility, as there can be an overlapping of their fields, so that careful consideration of all factors involved must be taken into account before the selection of one is made in favor of the other.

What are the factors to be considered in making the selection? Amongst the most important, are the following:

1. Required production.
2. Type of product.
3. Conversion cost.
4. Installation cost.
5. Flexibility.
6. Operational characteristics.

To make the matter of production more specific, let us consider the matter of the tonnage capabilities of the various mill arrangements for the product of tin plate. Taking as average width and gauge, 28 in. wide × 0.010 in. thick, and starting with 15 gauge (0.072 in.) off the hot mill, typical roll pass schedules might be about as follows:

2-Stand	3-Stand	4-Stand	5-Stand
0 — 0.072 in.	0 — 0.072 in.	0 — 0.072 in.	0 — 0.072 in.
1 — 0.052 in.	1 — 0.052 in.	1 — 0.052 in.	1 — 0.055 in.
2 — 0.022 in.	2 — 0.033 in.	2 — 0.023 in.	2 — 0.029 in.
3 — 0.014 in.	3 — 0.024 in.	3 — 0.014 in.	3 — 0.018 in.
4 — 0.010 in.	4 — 0.018 in.	4 — 0.010 in.	4 — 0.013 in.
	5 — 0.013 in.		5 — 0.010 in.
	6 — 0.010 in.		

Reversing Mill

0	—	0.072 in.	0.072 in.	0.072 in.
1	—	0.035 in.	0.036 in.	0.056 in.
2	—	0.022 in.	0.026 in.	0.034 in.
3	—	0.014 in.	0.018 in.	0.023 in.
4	—	0.010 in.	0.013 in.	0.017 in.
5	—	—	0.010 in.	0.013 in.
6	—	—	—	0.010 in.

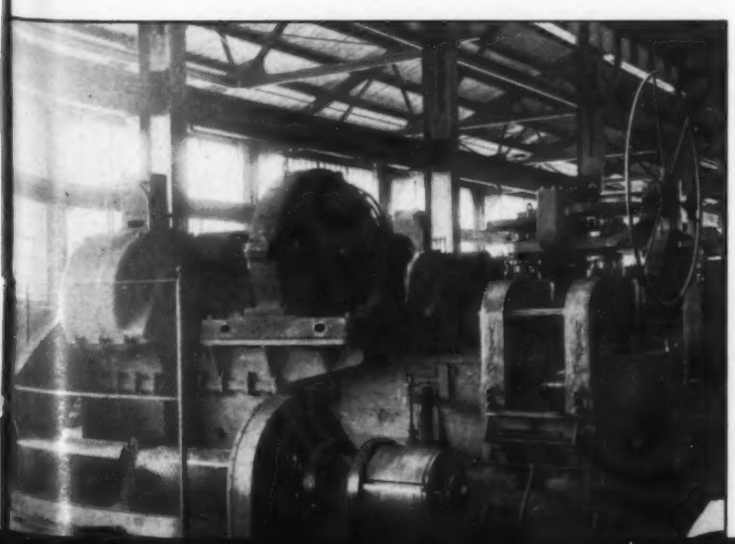
The pass schedules can be varied considerably from and around these figures, but in the case of the two and three-stand tandem mills, and the reversing mills, the passes are preferably chosen to keep fairly constant powers on the mill stands during successive passes, and in the latter case, fairly constant screw pressures as well. The four-stand, as compared with the five-stand requires somewhat greater reductions per pass, as does the two-stand; whereas the three-stand and the reversing mill can justify somewhat less reductions per pass. Sometimes this may lead to variations in starting gauge off the hot mill, but it also must be borne in mind that too light gauges off the hot mill requires, very often, greater rolling pressures, even though hot, than

the first pass in the cold mill. Lubrication is the determining factor. But reduction schedules alone do not tell the story. Along with multi-stand mills, comes the question of delivery speed out of the last stand. Because of the greater first cost, as the larger installations are considered, more and more emphasis is placed on delivery speeds. So we find four-stand mills running at finishing speeds of from 1500 fpm to 3000 fpm, whereas five-stand mills finish as high as 3500 fpm and are being projected up to 5000 fpm. Two-stand mills seem constant around 1000 to 2000 fpm, and reversing mills rarely exceed 1750 fpm.

This does not mean that there is any natural limit of finishing speed as a function of mill arrangement, but rather one of operational facility and economic compatibility. The weight and length of coil are also a determining factor. In many mills, 4000 to 8000 lb coils are common, having finished strip lengths of 5000 to 10,000 ft, obviously operating speeds of 5000 fpm would be out of order to consider, as the running time would be no more than 50 to 60 per cent of the operating time. Whereas for 20,000 to 40,000 lb coils, having lengths of from 25,000 to 50,000 ft the highest of practical speeds would still permit operating efficiencies of around 90 per cent. The matters of operational hazards, strip breakage, and attendant production delays, tension and speed control become of major concern at these higher speeds, and they still may be said to be desirable rather than attainable.

In the case of the paragon of production, the five-stand tandem mill, annual tonnages of 400,000 to 500,000 tons per year are possible; whereas its antithesis, the reversing mill, will produce at the rate of 60,000 to 80,000 tons per year, reaching in one known case, as high as 90,000 tons per year. Considerations of temper passing, very often influence the production picture. Where production requirements permit, cases have been considered of using a two-stand tandem, two-thirds of the time on reduction work, and one-third, on temper passing. Only minor provision need be made in construction to permit this, together with some care in production planning. The same is true of the reversing mill, where even less percentage of the time need be allowed for temper passing. In some few cases, particularly for low tonnage foreign mills, a semi-continuous hot strip mill has been proposed, with the finishing train convertible into a tandem cold mill, with some little

Figure 5 — Another early tandem cold strip mill which was built about 1915.



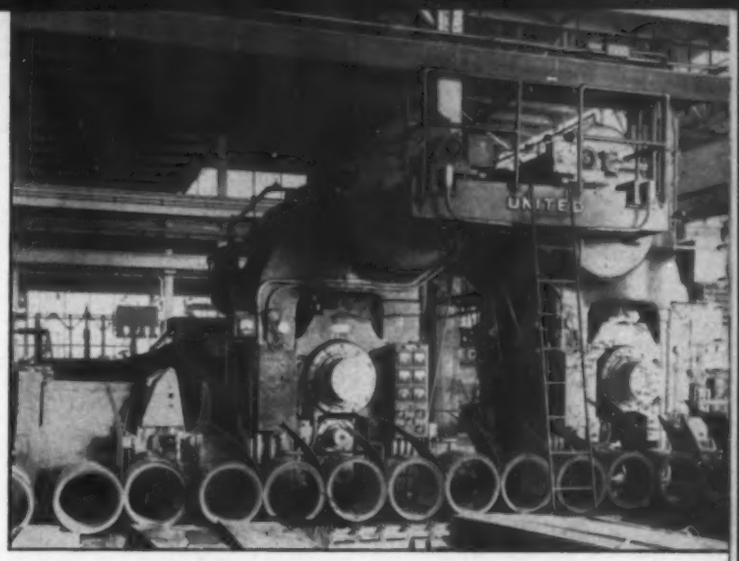


Figure 6 — This 2-stand tandem cold mill is used for cold rolling of brass. A conveyor transfers the coils around the mill.

complication, true, but not out of the realm of possibility and reason.

Whereas tin plate possibly typifies the large production item of fairly narrow physical and metallurgical specifications, say from 18 to 38 in. in width, and from 0.007 to 0.011 in. in gauge, but mostly from 24 to 30 in. and from 0.008 to 0.010 in.; there are many items that present the opposite picture. Stainless steel strip, or silicon (electric) sheets, or brass and copper strip, are production items that vary widely, and in not too large tonnages, for each specification. Whereas the tin plate industry reaches into the million of tons per year, stainless steel sheets and strip, for instance, hardly exceed 100,000 tons per year. Gauges vary from 0.005 to 0.030 in., and higher, as cold rolled, and from narrow bands, say 1 in., and up to 36 in. wide, and wider. Then too, wide variations in ultimate physical properties are required, from dead soft to full hard, and in widely differing chemistries, etc. For this class of product, the tandem cold mill is practically non-existent, no one producer having enough production to justify the cost of such an installation. Several sizes of reversing mills are usually indicated, both as to width, and as to size of work rolls, which is influenced considerably by the ultimate thinness of gauge, on this work-hardening material. Very often, in the earlier stages of reduction, the reversing mills are operated as one-way mills, with the coils being handled from delivery side to entry side somewhat as shown for the brass coils in Figure 6. Because of thermal and metallurgical restrictions, rolling speeds seldom exceed 500 fpm, or even reach it.

The production problem for silicon steels is similar in many respects to that of stainless, particularly where the high silicon (4 per cent), thin gauge material is produced. In some plants, where both stainless and silicon sheets are produced, the mills work interchangeably on both products to advantage. In one plant, there are eleven single stand mills, a few one-way, most reversing, of various widths and work roll sizes, to best produce the wide variety of specified products to which the plant caters.

In the brass industry, where the production is larger than that of the products just discussed, the variety of finish specifications still dictates a predominance of reversing mills with ever increasing refinements borrowed

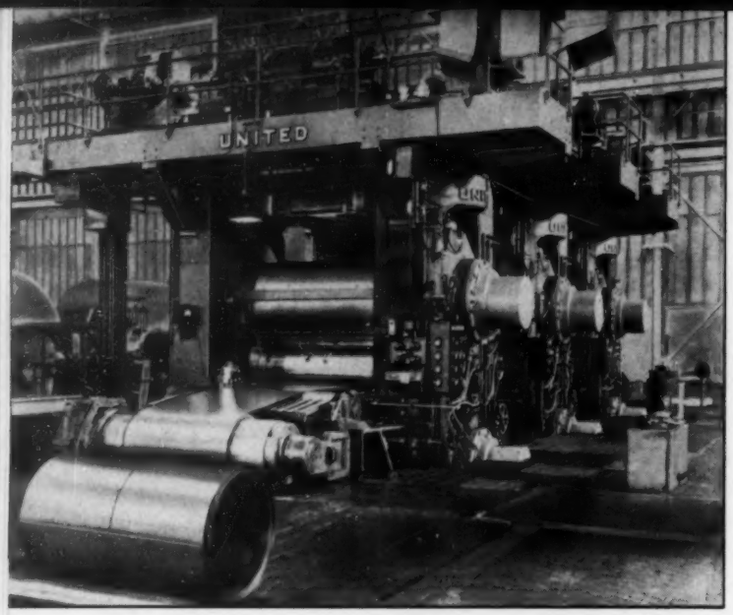


Figure 7 — Ninety-eight in., 3-stand tandem cold mill.

from the steel industry. The one-way mill, used because of the low weight of the "cake," and a desire to minimize scrap, is giving way to the reversing mill, by more general use of larger coils, made by welding together even larger initial coils, with its attendant reduction in rolling costs, and improvement in quality.

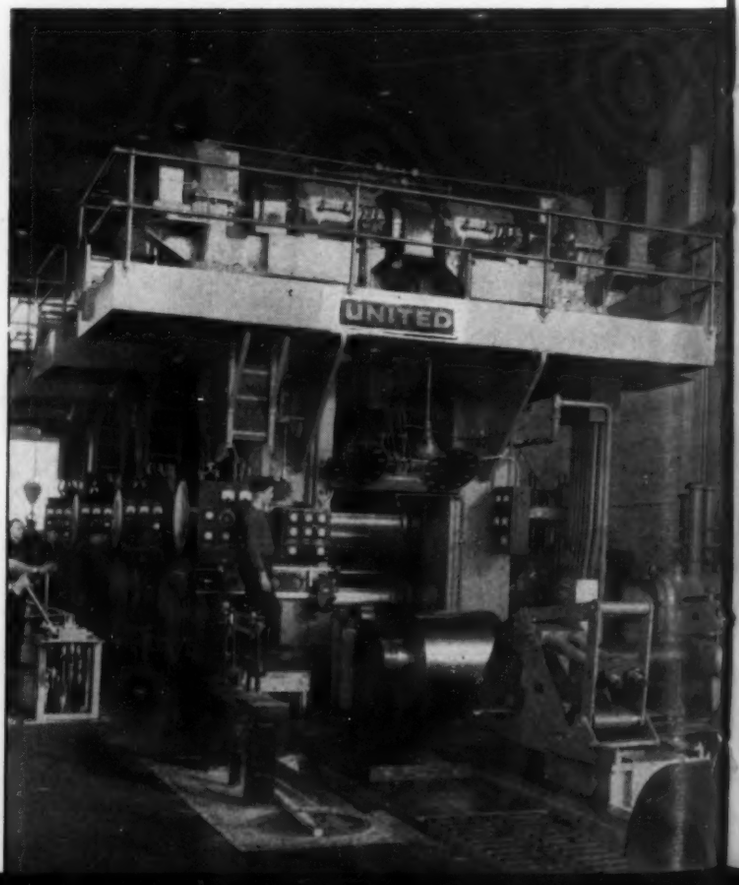
A good example of an intermediate field is perhaps the category usually captioned "sheets." This covers auto-body sheets, galvanizing stock, furniture stock, etc., where there is a generous intersprinkling of both tandem and reversing mills. The tandem mills, however, because of the heavier final gauges, ranging from 0.018 to 0.037 in., are more usually three-stand, with some two-stand and four-stand mills, as well. Reversing mills very often double as skin pass mills.

Some cursory statistics as to the number of cold mills throughout the country are interesting. In the tonnage plants (steel) where wide hot strip mills exist, there are roughly some 40 tandem mills, comprising about 150 roll stands, as against some 15 reversing cold mills. In the smaller cold rolling plants, however, the picture is almost the reverse, in that 85 per cent of the installed capacity is in reversing mills.

Of great importance in any consideration of choice of mills is the matter of cost, both installation cost and operation cost, the latter being considerably the more important for large producers. Tin plate again may serve to illustrate the various points. Taking 75,000 tons per year for the reversing mill, as against 450,000 tons per year for the five-stand tandem mill, we have a production ratio of say 6 to 1. The installation cost of a reversing mill will run around $600,000 as compared with say $2,500,000 for the complete tandem mill, approximately 4 to 1. Figuring fixed charges roughly as 1 per cent per month, we have figures of $1.04 per ton and $0.67 per ton as cost items reflecting initial investment costs, a $0.37 per ton saving in favor of the tandem mill. Direct labor is cheaper, too, based on a 7-man crew for the tandem mill, as against a 3-man crew for the reversing mill, the costs running around $0.60 per ton for the reversing mill, as against $0.25 per ton for the tandem mill. While electric power to reduce tin plate proper is closely the same for the two types of rolling, say 92 kwhr per ton for the tandem mill as against 95 kwhr per ton for the reversing mill, there is a considerable difference for the auxiliaries. The power consumption for such items as motor ventilation, mill heating, crane service, lighting, lubricant and coolant pumps, screw-down motors, etc., may reach 50 kwhr per ton for the reversing mill installation, as against about 23 kwhr per ton for the tandem mill. These figures total 145 kwhr per ton for the reversing mill versus 115 kwhr per ton for the tandem mill, which when priced at $0.005 per kwhr results in $0.72 per ton as compared to $0.57 per ton, a difference of $0.15 per ton. Roll coolant and lubricant costs, however, show the reverse picture. Because of the general use of palm oil in tandem tin plate rolling as compared to a circulating soluble oil system, for reversing mills, the tandem mill lubricant costs may exceed that of the reversing mill by as much as $0.25 per ton. The matter of rolls, however, because of the more rapid wear of rolls under reversing service, may show a figure of $0.75 per ton for reversing mill as against $0.50 per ton for tandem rolling. Although these figures amount to only about half of the contributing cost items, they cover primarily the major points of comparison. Thus we see that five-stand tandem rolling may show a saving of between $0.75 and $1.00 per ton over the reversing mill, provided that sufficient tonnage is available in each case to keep the respective mills running at capacity.

The question might be asked whether it would pay the small producer to put in the tandem mill, in order to obtain the lower conversion cost. The question is easily answered by considering the increase in carrying

Figure 8 — This typical 4-stand tandem mill is used for tin plate.



charges that would be involved. The initial figure of $0.67 per ton would be increased to six times this figure (based on one-sixth the tonnage), making an increase in cost of $3.35 per ton, which would exceed the margin of the tandem mill (at full production) over the reversing mill by some $2.50. More often than not, small producers, by their very size are capable of offsetting such conversion cost handicaps by generally lower overhead and plant versatility. When orders are off, the tandem tin mill is generally idle. But the reversing cold mill can shift from tin plate to sheet stock, or stainless, or into the general cold reduced market, with relative ease. This flexibility of the reversing cold mill is obviously a factor of fluctuating importance, but is particularly valuable in slower production periods.

Perhaps something should be said about the relative operating advantages and disadvantages of the two types of mills. To attain the large tonnages produced off the tandem mills, the most expert of operators is required. The maintenance of interstand tension still requires continuous alertness, even though tensiometers now indicate the magnitude of that tension. The fact that automatic interstand tension has not as yet been satisfactorily solved, attests to the delicacy of this problem. Then, too, the production tie-up resulting from strip breakage and cobbles is ever present. Despite these hazards, tandem mill rolling speeds are considerably in excess of reversing mill speeds, and still increasing.

Despite the high speeds used, roll wear, and maintenance of good work roll surfaces are easier in the tandem mill than in the reversing mill. It is now accepted that the effect of contact roll stress reversals more rapidly fatigues and wears the roll surface, thus necessitating more vigilance on the part of the operators, wishing to maintain only first quality surface. The fact that in the reversing mill, the one pair of work rolls are the finishing rolls as well as the roughing rolls, means more frequent roll changes. In the tandem mill, as the finishing stand rolls start to roughen up, they can be used in previous stands, and thus utilized to better advantage, with less dressing required. This prerogative, however, prevents the use of different work roll sizes in the various stands, which advantage is of doubtful value, anyhow.

The matter of rolling lubricants, and roll cooling seem to have worked out differently in the two types of mills. Whereas the general use of palm oil in the tandem rolling of tin plate has justified itself economically, the opposite is true for the reversing mill. Attempts to use it there, other than in special cases, result in too hot a mill, and difficult rolling conditions. Cooling is obtained at the sacrifice of reduced rolling friction, when soluble oil is used instead of palm oil. For the tandem rolling of sheet gauges, and for non-ferrous rolling, however, soluble oil is adequate, and less expensive.

A point of difference between the two types of rolling lies in the amount of end scrap produced. Since a certain amount of strip at each end of the coil must be retained in the tension reels, scrap corresponding to about 20 ft strip per coil at its original gauge, must be charged against the economics of reversing mill rolling. Where more costly material is involved, or where short coils are necessarily being rolled, very often, in the earlier stages of rolling, the mill is operated as a one-way mill.

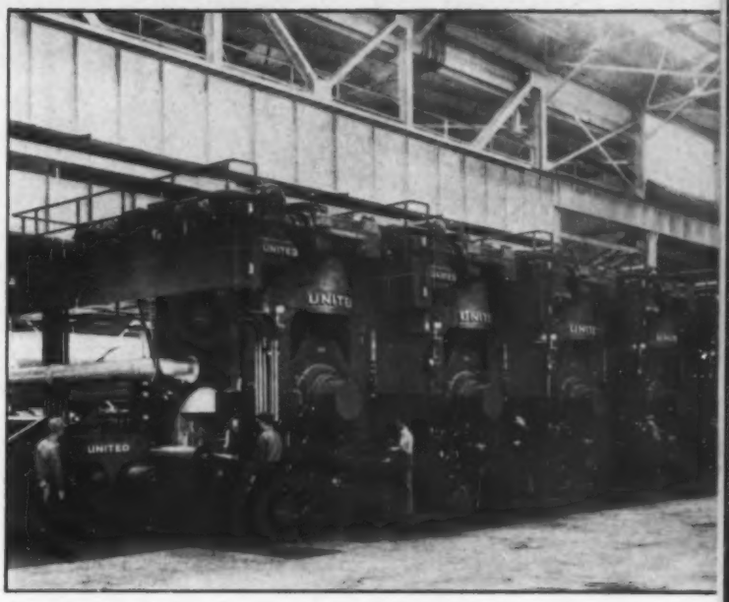
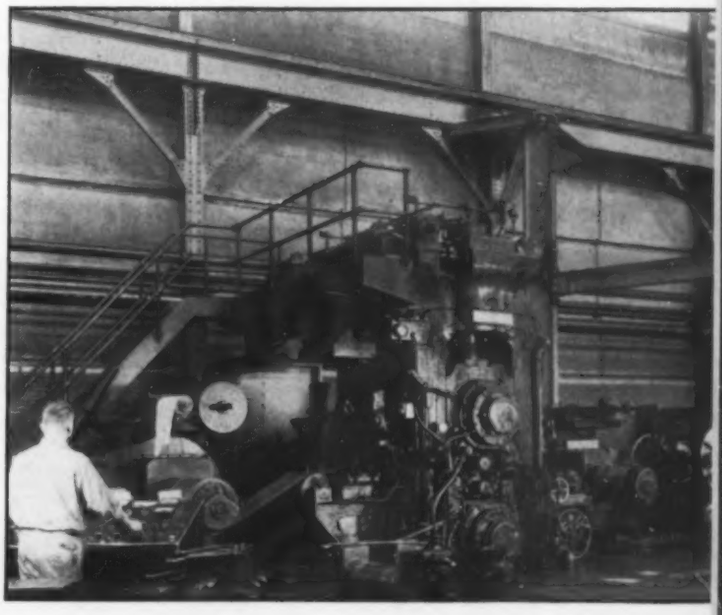


Figure 9 — High speed production of tin plate is accomplished on this 5-stand, tandem, cold reducing mill.

In either the tandem or the reversing mill, however, there is a certain amount of off gauge material at each end of each coil, due to inadvertent gauge changes, during acceleration and deceleration periods. The reduction in speed is accompanied by an increase in gauge, whereas one might normally expect the contrary, based on the fact that metals usually reduce more easily at lower speeds. There is a curious reversal in this relationship for low carbon steels at temperatures around 300 to 400 F, however; and this, coupled with the fact that any semblance of an oil film in the roll bite during its higher speeds is lost at the lower speeds, results in heavy off-gauge end scrap. Attempts at tapered tension control, increasing the tension gradually as the speed is reduced, and other devices, have only partially offset these effects.

In the earlier passes of rolling, it is always possible to reduce the material faster in a reversing mill than in

Figure 10 — This typical, small, 4-high, reversing cold mill for stainless steel has collapsible tension reels.



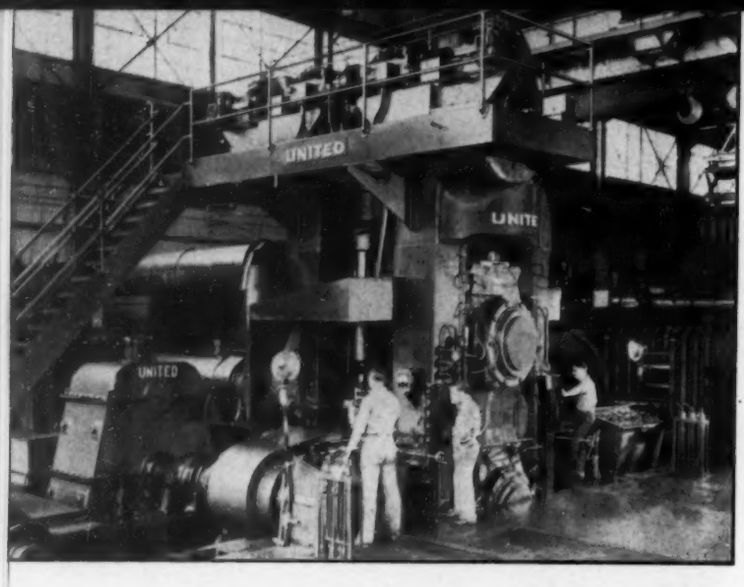


Figure 11 — This typical 4-high reversing cold mill for tin plate has removable solid reel drums.

the first stands of the tandem mill. A 1500 fpm reversing mill is powered such that the earlier passes of a 7-elongation schedule may be rolled at say 700 to 1000 fpm, while the entry speed, at best, of a tandem mill would be constrained to be $1/7 \times 1500 = 214$ fpm, finishing probably at 300 fpm. Despite this and similar points, however, the tandem mill remains the production mill, par excellence.

A point of some value for the operator of a reversing mill is his ability to choose his rolling schedule at will. An extra pass or two might mean the difference between a wavy strip and a flat strip; or a more difficult schedule, or lighter final gauge, may easily be accommodated. This flexibility of the reversing mill, as compared to the tandem mill, in rolling operation, as well as type of products that may be handled, is of considerable economic import.

A summary of this paper would almost be a recapitulation of the various points made. The thought that must necessarily be left with us is that the reversing mill offers lower investment cost and greater flexibility, whereas the tandem mill emphasizes lower operating cost and greater production. Both types of mills will remain important in any general steel company production picture.

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2. Authority for this information is A. W. Soderberg, formerly chief engineer, Homestead plant, Carnegie-Illinois Steel Corporation.

DISCUSSION

PRESENTED BY

J. A. CLAUSS, Vice President in Charge of Engineering, Great Lakes Steel Corporation, Ecorse, Detroit, Michigan

M. D. STONE, Manager, Development Department, United Engineering and Foundry Company, Pittsburgh, Pennsylvania

J. E. McBRIDE, Vice President, Palmer-Bee Company, Detroit, Michigan

J. A. Clauss: Mr. Stone has covered the subject thoroughly, and I was very much interested in his history of rolling mills.

From the crude mills to the present-day 4-high cold mills as described by Mr. Stone, which are in reality precision machines, it is evident that much progress in design has taken place, also in the quality and the amount of material rolled.

About 1923, after Mr. Stone's company installed a 4-high mill at the Rome Copper and Brass Company, there was a renewed interest in 4-high mills.

When 4-high mills were proposed for the continuous rolling of hot strip steel to replace the conventional 2-high, cross-country type of mill then in use for the rolling of bands or strip, many rollers believed that you could not roll strip steel when the rolling was all in one direction. It was contended that you had to roll strip steel back and forth.

The 4-high hot and cold strip mills as we know them today have been developed during the past twenty-three years. Remarkable progress has been made in their design, speed and production. Where a few years ago cold rolling was limited to comparatively narrow widths in two-high mills, with hand-operated screw-downs, having a speed of from 100 to 200 fpm, we have today 4-high cold mills rolling 90 in. wide material, with electric screw-downs and running at speeds up to 3500 fpm.

A few years ago cold rolling of steel for tin plate was thought impossible. A number of 4-high cold mills are in operation today rolling steel to tin plate gauges at speeds up to 3500 fpm. At the present time there are under construction 4-high cold mills with reported speeds of close to 5000 fpm.

Regarding the relative advantages of the 4-high tandem cold mill and the 4-high reversing cold mill, both have their places in the industry and the kind of mill selected will be determined by the tonnage desired, the cost of the installation, and the product to be rolled. We have in Detroit three successful 4-high reversing cold mill installations.

M. D. Stone: I should like to ask Mr. Clauss if he remembers when they had steam engine driven screw-downs? I have been told they used two steam engines on top of the old mills, one for each screw.

J. A. Clauss: I do not remember having seen any steam operated screw-downs. Years ago there were many hydraulic operated screw-downs, in fact there are mills in operation today with hydraulic screw-downs.

J. E. McBride: I would like to ask Mr. Stone something about the temperature that he mentioned, 400 F temperature of roll.

M. D. Stone: From 300 to 400 F is about the temperature cold strip reaches in rolling through the mills. That is, the heat generated by reduction partly goes into the mill rolls and is radiated or conducted away, but part of it goes into the strip and heats the strip.

Gearing.....

FOR STEEL MILL AUXILIARIES AND CRANES

.... the 20 degree tooth form has inherent advantages over the 14½ degree pressure angle, since surface compressive stress is decreased, the number of teeth in the arc of action is increased, and the beam strength of the tooth is increased ...

By L. J. COLLINS, Gear Engineering Division
General Electric Company, West Lynn, Massachusetts

▲ THE primary purpose of the following paper is to present certain facts pertaining to the choice of pressure angles in the design of gear teeth. Since the pressure angles most commonly employed are 14½ and 20 degree, the subject matter will be restricted to a discussion of these two angles.

In order that the material shall present as clear a picture as possible, every effort will be made to avoid the use of mathematical equations, except where such equations are deemed absolutely necessary.

GENERAL DESIGN CONSIDERATIONS

Application — The application of gearing to steel mill auxiliaries and cranes is such that it is desirable, if not mandatory, to install a gear train which will transmit maximum power in the smallest possible space. If a gear train is to occupy a small space, the center distance is limited. The gear ratios required determine the diameters of the pinion and gear which will fit the center distance specified. In Table I which follows several actual combinations are listed as examples.

Smoothness of operation — The gear train should be designed and manufactured to operate without undue noise or vibration. Noise in itself may not be objectionable in many installations due to the general noise level of the mill or factory. However, noisy gearing indicates that the tooth engagements are not smooth or that undesirable manufacturing errors exist.

Starting torque — The starting torque on the gearing is high, and in general is several times the normal rated full load torque. The high starting torque will impose a very heavy stress in the root fillet of the tooth, and tooth breakage may result.

Distributing the load — The teeth should be so proportioned that more than one tooth is in the arc of action. The general procedure in calculating the stress on the surface of a tooth, or in the root fillet is to assume all the load as being concentrated at the tip of one tooth. With more than one tooth in the arc of action, this condition will not be encountered, and the maximum stresses on the tooth surface or root fillet will actually be less than indicated by the calculations referred to above.

The face width — It might be reasoned that since the diameters of gear and pinion are limited by the center distance and ratio, the gears can be made to carry more load by increasing the face width. The face width may be increased within reasonable limits, but we must bear in mind that if the pinion is small in diameter, the torsional deflection, bending deflection and tooth deflection of the pinion may be sufficient to render a portion of the face width ineffective.

Tooth form — The standard tooth form employed by the gear industry is the involute. One of the desirable characteristics of involute gearing is that these gears will perform satisfactorily, even though reasonable variations in center distance are encountered. The most

TABLE I

Various Combinations of Gears for Different Center Distances

Number of teeth		Diameter pitch	Diameters		Center distance	Ratio
Pinion	Gear		Pinion	Gear		
15	76	4	3.75	19	11.375	5.07
17	84	4	4.25	21	12.625	4.94
18	89	4	4.50	22.25	13.375	5.94
19	96	3	6.33	32	19.167	5.05
20	93	4	5.00	24.75	14.875	4.95

Presented before AISE Annual Convention, Cleveland, Ohio, October 1, 1946.

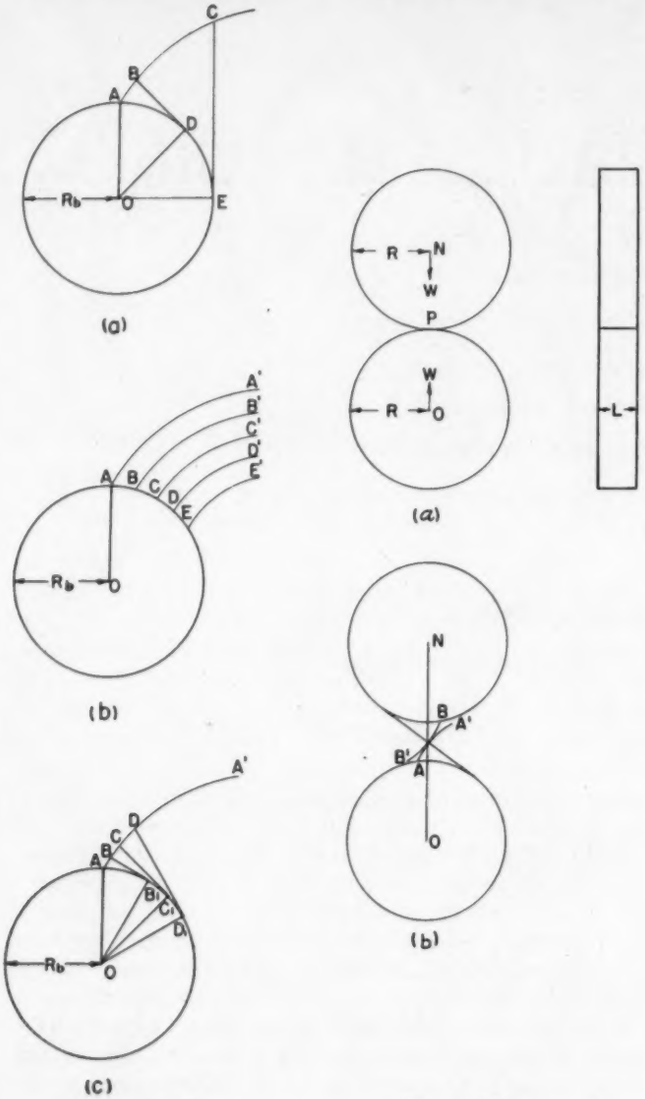


Figure 1 ↑

Figure 2 ↑

Figure 1 — The standard tooth form is based on the involute which is the curve formed by unwrapping a string from a cylinder. (Left column)

▲

Figure 2 — Contact pressures between two cylinders vary with the radii of the cylinders. (Right column)

common cause of variations in center distance is due to wear in the supporting bearings.

The involute is defined as the curve traced by a point on a stretched string as it is unwound from a circle called the base circle. An involute curve A-B-C is shown in Figure 1a, and was developed by unwinding the string C-E from the base circle, whose center is at 0, and whose radius is R_b.

Since the curve A-B-C is being traced by a point on a stretched string as it is unwound from the base circle 0, it is evident that the generating radii B-D and C-E are tangent to the base circle 0, at points D and E respectively; and that angles BDO and CEO are right angles.

In an actual gear, or pinion, the faces of the teeth are portions of the involute curves A-A', B-B', etc. shown in Figure 1b. The circular distances A-B, B-C, C-D, D-E, etc. are equal in length, the lengths being de-

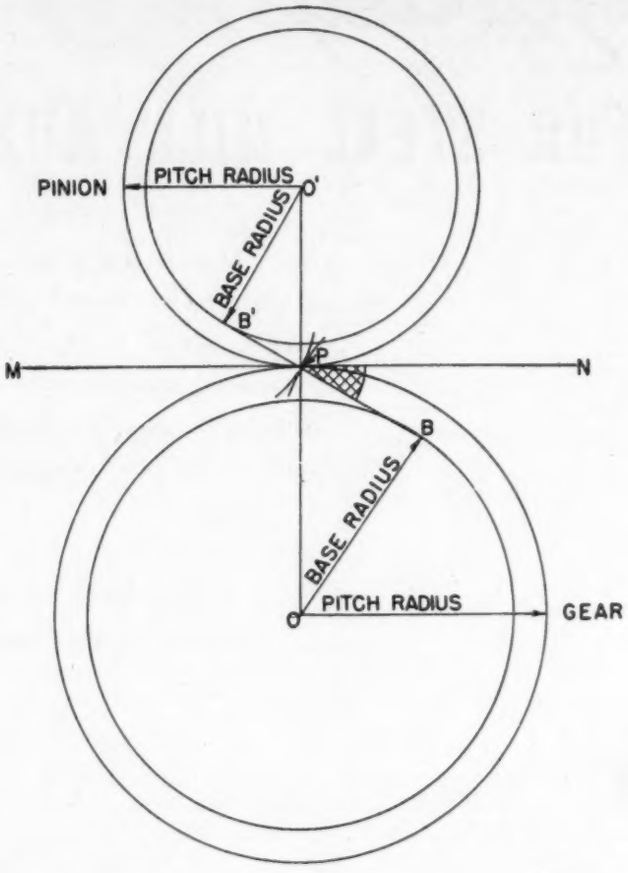
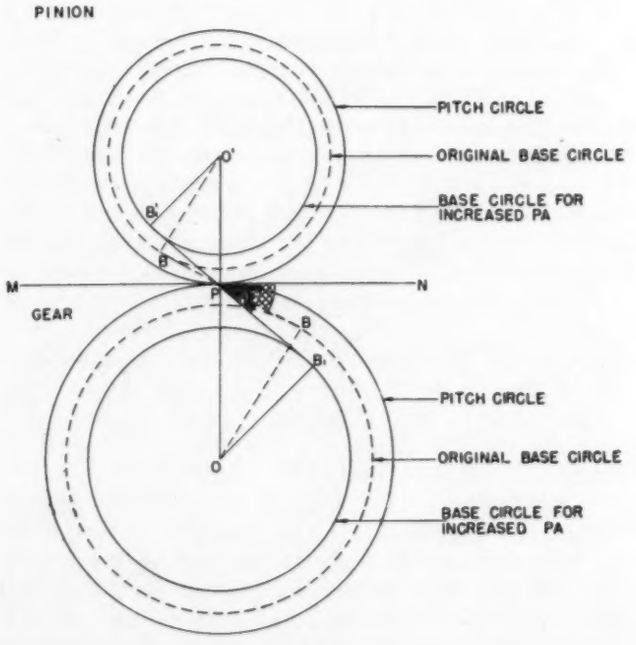


Figure 3 — The pinion and gear are in contact at pitch point P.

▲

Figure 4 — The radii of curvature of the teeth in contact at the pitch point increase when the pressure angle is increased.



pendent upon the number of teeth on the gear or pinion, and the diameter of the base circle.

If we consider three points, B, C, D, on the involute curve A-A′ Figure 1c, we find that the radii of the curve at these points are B-B_1, C-C_1 and D-D_1. It is also evident from Figure 1c, that B-B_1 is a smaller radius than either C-C_1 or D-D_1. If now we consider the involute curve A-A′ Figure 1c as representing one face of a tooth on a gear or pinion, we see that when the tooth is contacting its mating tooth at point B, the radius of curvature at the point of contact is B-B_1. For this condition, the radius of curvature at the point of contact is smaller than it would be, had point C or D been chosen as the point of contact.

EFFECT OF RADIUS OF CURVATURE AT POINT OF CONTACT UPON LOAD CARRYING ABILITY OF GEAR TEETH

In Figure 2a, two cylinders of equal radii R, and equal length L, are shown in contact at point P. If no pressure is exerted to force the cylinders into more intimate contact, the area of contact may be represented by a line. Under this condition, the area of contact approaches zero.

If now the two cylinders are acted upon by a pressure W, tending to force them into more intimate contact, there is a tendency for the cylinders to flatten out at point P. Under this condition, the pressure between the two cylinders is distributed over a finite area.

If the radii of the two cylinders remain equal and increase to infinity, the area of contact increases also, until P becomes a point on two contacting parallel planes. Conversely, if the radii remain equal and decrease, the area of contact becomes smaller and smaller, and the unit stress at P becomes greater and greater.

Hertz expressed the compressive stress at point P Figure 2a by the following equation:

$$S_c = 0.583\sqrt{W\frac{\frac{1}{R_1}+\frac{1}{R_2}}{\frac{1}{E_1}+\frac{1}{E_2}}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where W = unit loading per inch of length
R_1 and R_2 = radii of curvature
E_1 and E_2 = moduli of elasticity

If the two cylinders are made of steel, the values of E_1 and E_2 are constant, and the above equation may be written:

$$S_c = 0.583\sqrt{(W)\frac{\frac{1}{R_1}+\frac{1}{R_2}}{K}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where $K = \frac{2}{30\times 10^6}$

The above equation indicates that the larger we make R_1 and R_2, the smaller becomes S_c, and conversely, the smaller R_1 and R_2 become, the greater becomes S_c.

Table II has been compiled simply to indicate the rate at which S_c increases as the radii R_1 and R_2 decrease.

TABLE II

Variation of Compressive Bearing Stress with Surface Radii of Curvature

Pressure on cylinders "W" = 900 lb

Moduli of elasticity = 30 x 10^6 psi

R_1	R_2	S_c
10	10	1010
9	9	1060
8	8	1125
7	7	1201
6	6	1238
5	5	1422
4	4	1491
3	3	1836
2	2	2250
1	1	3173

In Figure 3 a pinion and gear tooth face are shown in contact at the pitch point P. The pitch radius of the pinion is PO′, and the pitch radius of the gear is PO. The angle of obliquity, or pressure angle BPN, is shown crosshatched. Angles POB and PO′B′ are equal to the pressure angle, since the sides are mutually perpendicular. The radii of curvature of the pinion and gear teeth are PB′ and PB respectively. These radii are tangent to their respective base circles at B′ and B, as shown in Figure 3.

The two surfaces in contact at P may be considered as two cylindrical surfaces of radii PB′ and PB. The compressive stress at the point of contact may then be calculated by substituting in equation (2).

If the pressure angle and pitch diameters of the gear and pinion are known, the radii of curvature at the point of contact may be determined as follows:

Angle B′O′P = BOP = pressure angle = PA

Base radius of pinion O′B′

$O'B' = O'P \cos PA$ ..... (3)

Base radius of gear OB

$OB = OP \cos PA$ ..... (4)

Expressed in words, the base radius of a gear, or pinion, is equal to the pitch radius of the gear, or pinion, multiplied by the cosine of the pressure angle.

When the base radii are known, the radii of curvature of the tooth surfaces at the point of contact may be calculated as follows:

For the pinion $PB' = O'B' \tan PA$ ..... (5)

For the gear $PB = OB \tan PA$ ..... (6)

Expressed in words, the radius of curvature of a gear or pinion tooth at the pitch point is equal to the base radius of the gear or pinion, multiplied by the tangent of the pressure angle.

These radii are often calculated as follows:

For the pinion $PB' = O'P \sin PA$ ..... (7)

For the gear $PB = OP \sin PA$ ..... (8)

Although the results obtained from equations (7) and (8) are the same as for equations (5) and (6), a clearer picture is obtained by determining the base radii, and constructing the triangles shown in Figure 3.

That the radii of curvature of the teeth in contact

at the pitch point increase when the pressure angle is increased, is shown in Figure 4.

Increasing the pressure angle from BPN to B_1 PN resulted in the following changes:

Base radii —

1. OB decreased to OB_1
2. O′B′ decreased to $O'B'_1$

Radii of teeth at point of contact —

1. PB increased to PB_1
2. PB′ increased to PB_1'

Since the radii of curvature at the pitch point increased, due to an increase in pressure angle, the compressive stress on the tooth surface decreased in accordance with equation (2).

The values given in Table III were taken from an actual design, to show the decrease in compressive stress obtained by increasing the pressure angle.

TABLE III

Variation in Compressive Stress with Pressure Angle for a 19 Tooth Pinion Meshing with a 96 Tooth Gear

Pressure angle	14½ degree standard	20 degree stub
Number of teeth	19	19
Diametral pitch	3	3
Tangential driving pressure	3150	3150
Compressive stress, normal	72000	62000
Compressive stress, stalled maximum	160000	139000

For this particular combination, a 20 degree stub tooth will transmit 33 per cent more power than a 14½ degree standard tooth for the same value of compressive stress.

TEETH IN THE ARC OF ACTION

Determining the teeth in the arc of action is a comparatively simple task, as will now be indicated. That portion of the line of action, during which the teeth are actually in engagement, is equal in length to the distance between the points at which the pinion and gear addendum circles intersect the line of action. This distance is represented by MN Figure 5. Since the faces of the teeth are portions of a family of involute curves D-D′, E-E′, etc., the normal pitch Pn Figure 5 is equal in length to the distance between tooth faces measured along the line of action.

If then, that portion of the line of action MN is known, the quotient obtained by dividing the distance MN by the normal pitch, will give the number of teeth in contact.

The distance MN may be determined as follows:

First —

Determine the distance B′B. This distance is equal to the center distance C, times the sine of the pressure angle.

$$B'B = C \sin PA \qquad (9)$$

Second —

Determine the length of the lines B′N and BM as follows:

$$B'N = \sqrt{(O'N)^2 - (O'B')^2} \qquad (10)$$

where O′N = Outside radius of pinion.
O′B′ = Base radius of pinion.

$$BM = \sqrt{(OM)^2 - (OB)^2} \qquad (11)$$

where OM = Outside radius of gear
O B = Base radius of gear.

Third —

Add B′N+BM and subtract B′B and the difference is MN.

$$(B'N + BM) - B'B = MN \qquad (12)$$

Fourth —

Determine the normal pitch Pn.

The normal pitch Pn Figure 5 is equal to the circumference of the base circle, divided by the number of teeth generated from this base circle.

$$Pn = \frac{2\pi(OB)}{N_G} \qquad (13)$$

or

$$Pn = \frac{2\pi(O'B')}{N_P} \qquad (14)$$

where N_G = Number of gear teeth
N_P = Number of pinion teeth.

When the number of teeth on the pinion is small, as is the case in the type of gearing being discussed, increasing the pressure angle from 14½ to 20 degrees will increase the number of teeth in contact. Table IV has been prepared to illustrate.

TABLE IV

Variation of Contact Ratio with Pressure Angle

Number of teeth		Contact ratio	
Pinion	Gear	14½ degree standard	20 degree stub
15	76	0.97	1.36
17	84	1.13	1.38
18	89	1.23	1.38
19	96	1.31	1.39
20	99	1.38	1.39

TOOTH STRENGTH

Referring to Table I, we note that the pinion tooth numbers vary between 15 and 20 teeth. It could be reasoned that smoother action would result through the use of more and smaller teeth. While this is true, we are forced to choose teeth of sufficient beam strength to withstand the heavy loads.

In Figure 6 is shown the pitch circles of a pinion and gear of pitch radii D_p and D_g respectively. Now, regardless of the numbers of teeth on the gear and pinion, if the pressure angle is given, the base circle radius of the pinion and gear is established. In this particular instance, the pressure angle APN was chosen, and the line of action APE was drawn. The base circles of the pinion and gear are tangent to the line of action at B′ and B respectively. The radial distance T between the pitch and base circles of the pinion is smaller than for the corresponding distance U measured on the gear.

Further study of Figure 6 will reveal that unless very small teeth are cut on the pinion and gear, the following conditions will be encountered:

1. The pinion teeth
   Long Addendum
   Short Dedendum

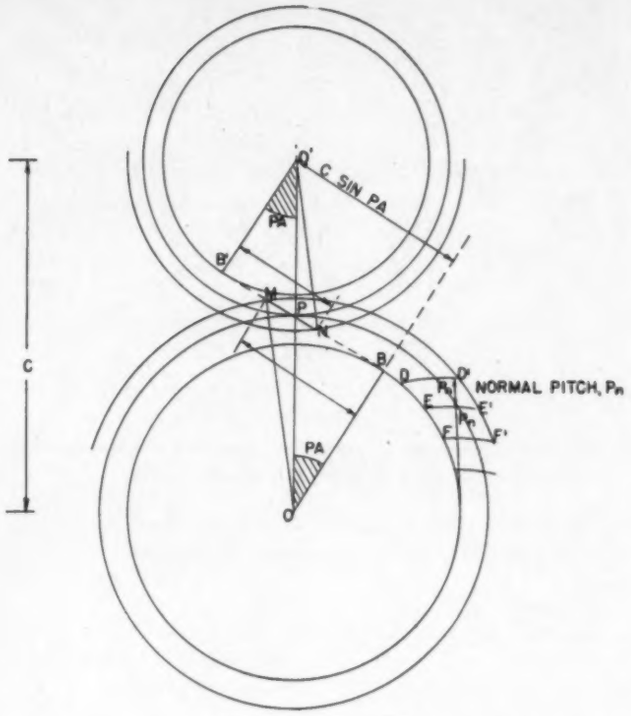


Figure 5 — Teeth are in engagement for a distance equal in length to the distance between the points where the pinion and gear addendum circles interesect the line of action.

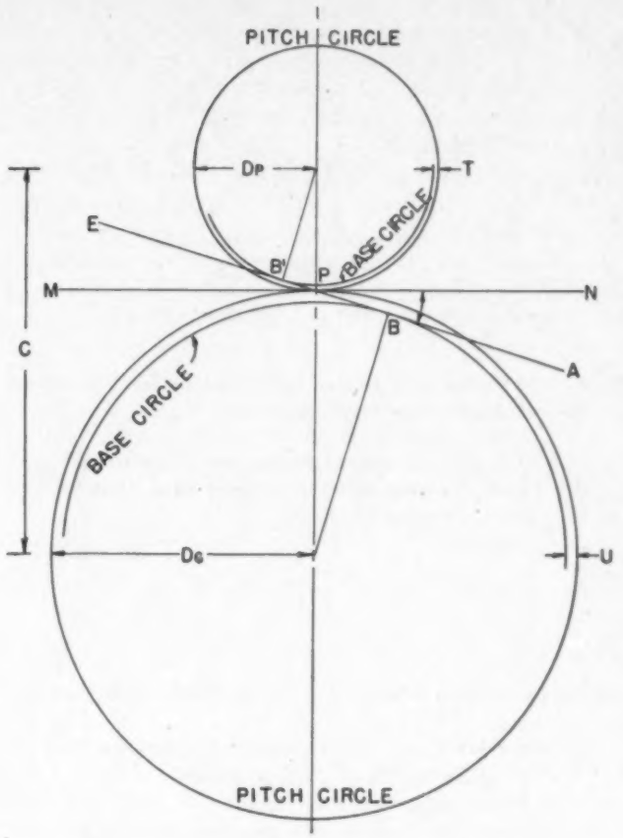


Figure 6 — Pitch circles of gear and pinion.

2. The gear teeth
   Short Addendum
   Long Dedenum

Under these conditions there may be an excessive amount of sliding between the addendum of the pinion tooth and the dedendum of the gear tooth, which is undesirable from a wear standpoint. The gear tooth will be weaker than the pinion tooth from a beam standpoint.

If an effort is made to increase the dedendum of the pinion teeth, the cutter or hob will cut below the base circle, and undercutting of the teeth will result.

The most logical procedure to follow, in view of the above, is to increase the radial distance T, Figure 6, between the pitch circle and the base circle. This can be accomplished only by increasing the pressure angle. See Figure 4.

Figures 7 and 8 have been drawn in an attempt to show this condition. It will be noticed in Figure 7 that the distance between the pitch and base circles of the 19 tooth pinion is small. The hob, or cutter, will produce an involute curve from the tip of the tooth to approximately the base circle. Below the base circle, the tooth is undercut as the hob or cutter advances. The resulting tooth has therefore been weakened at the root, due to undercutting.

In Figure 8 is shown a tooth of the same pitch used in Figure 7. In this case, however, the pressure angle has been increased, thus causing the radial distance between the pitch and base circles to increase. In addition to this change the addendum of the tooth has been decreased by 20 per cent. The tooth is not undercut, and is very much thicker through the root than the tooth shown in Figure 7. The beam strength of the tooth pictured in Figure 8 is stronger than that of the tooth pictured in Figure 7 by virtue of the fact that it is a shorter and thicker tooth.

Thus far we have consdered two of the advantages to be gained by increasing the pressure angle of the teeth on pinion where the tooth numbers are low.

1. The surface compressive stress was reduced.
2. The number of teeth in the arc of action was increased.

A visual examination of Figures 7 and 8 will convince one of the fact that for a given applied load the beam strength of the tooth represented in Figure 8 is greater than that of the tooth represented in Figure 7.

It is common practice in the gear industry to consider the total load applied to the tip of a gear tooth, as indicated by W, Figures 9 and 10. However, if there is more than one tooth in the arc of action, it will be found that the point of worst application, as determined graphically, occurs at some other position, such as P of Figures 9 and 10.

The following is one method of determining the stress in the root of the tooth, and is based on the original Lewis equation, which was first presented by Mr. Lewis in the Proceedings of the Engineers Club, Philadelphia, Pennsylvania, January 1893, and in the American Machinist, June 22, 1893.

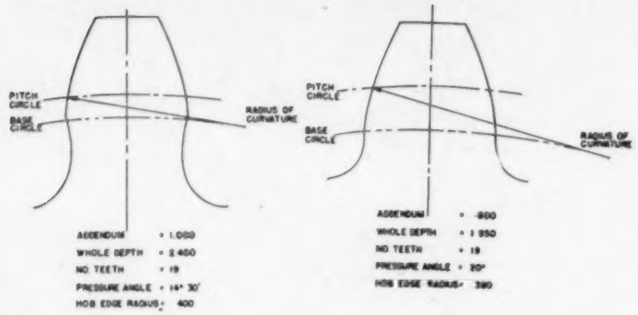


Figure 7 — In the 14½ degree form, the distance between the pitch and base circle is small. (Left)

Figure 8 — In the 20 degree form, the distance between the pitch and base circle is greater than that for the 14½ degree form. (Right)

$$T = SFPy \qquad \ldots\ldots (15)$$

where T = load in pounds, "tangential component of W"
S = stress intensity pounds per square inch
F = face width of gear in inches
P = circular pitch in inches
y = tooth form factor. Determined graphically.

First, the pinion is drawn to such a scale that the size of the teeth is one diametral pitch. The parabola, ABC, is drawn so that its vertex B is at the point where the line of worst application intersects the radial line, through the middle of the tooth. The parabola is drawn tangent to the root fillets at the end of the line A-C through the weakest section of the tooth.

Second, from the vertex B, a line is drawn to A, and A-D is drawn at right angles to A-B from A until it cuts the radial line B-D. The line B-D is thus divided into two parts h_1 and x.

Third, the beam inclosed by the parabola is a beam of constant strength, the equation of which is

$$T = \frac{SFt_1^2}{6h_1} \qquad \ldots\ldots (16)$$

where t_1 = the beam thickness in inches
h_1 = length of beam in inches.

Equations (15) and (16) are both equal to T, therefore we may write:

$$SFpy = \frac{SFt_1^2}{6h_1} \qquad \ldots\ldots (17)$$

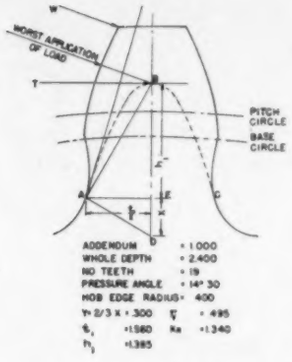
Simplifying

$$py = \frac{t_1^2}{6h_1} \text{ and } y = \frac{t_1^2}{6h_1 p} \qquad \ldots\ldots (18)$$

From triangles ABE and AED Figures 9 or 10

$$x : \left(\frac{t_1}{2}\right) = \left(\frac{t_1}{2}\right) : h_1 \qquad \ldots\ldots (19)$$

or $$t_1^2 = 4h_1 x \qquad \ldots\ldots (20)$$



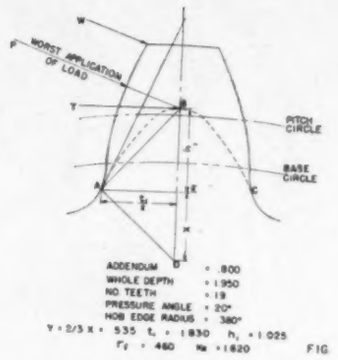


Figure 9 — Graphical solution for tooth form factor for Lewis formula for 14½ degree tooth. (Left)

Figure 10 — Graphical solution for tooth form factor for Lewis formula for 20 degree tooth. (Right)

Substituting equation (20) in equation (18)

$$y = \frac{4h_1 x}{6h_1 p} = \left(\frac{2x}{3p}\right) \qquad \ldots\ldots (21)$$

Equation (15) may now be written

$$T = SFP\left(\frac{2x}{3p}\right) = SF\left(\frac{2x}{3}\right) \qquad \ldots\ldots (22)$$

The values of x may be measured from Figure 9 or 10 and the values of y determined. If the tooth has been drawn to the size of one diametral pitch, the value of y determined in this way must be divided by the diametral pitch of the teeth being calculated. Since equation (22) was for one diametral pitch, when it is corrected to the diametral pitch being investigated, it will read:

$$T = SF\left(\frac{2x}{3}\right)\frac{1}{P} \qquad \ldots\ldots (23)$$

Letting $\left(\frac{2x}{3}\right) = Y$, we may write

$$T = \frac{SFY}{P}, \text{ whence}$$

$$S = \frac{T \times P}{F \times Y} \qquad \ldots\ldots (24)$$

where T = tangential component of load
P = diametral pitch
F = face width
Y = the form factor for one diametral pitch teeth
S = bending stress intensity, psi.

In general, equation (24) is used in the design of spur gear teeth. In the case of highly loaded gears, which operate at very high speeds, other factors must be considered such as:

1. Stress concentration in the root fillet.
2. The plasticity of the gear material.

When these factors are taken into consideration, equation (24) will be altered as follows:

$$S = \frac{(T)(P)}{(F)(Y)}\left[1+(K_R-1)m\right] \qquad \ldots\ldots\ldots (25)$$

where m = the plasticity factor

K_R = the fillet radius concentration factor.

See, "A Photoelastic Study of Stresses in Gear Tooth Fillets", by Thomas J. Dolan and Edward L. Broghamer, University of Illinois Bulletin — Vol. XXXIX March 24, 1942, No. 31.

The values given in Table V were calculated for the same combination used in determining the values tabulated in Table III.

TABLE V

Variation in Root Stress with Pressure Angle for a 19 Tooth Pinion Meshing with a 96 Tooth Gear

Pressure angle	14½ degree standard	20 degree stub
Number of teeth	19	19
Diametral pitch	3	3
Tangential driving pressure	3150	3150
Root stress, normal	8450	5700
Root stress, stalled maximum	39400	27750

For this particular combination, a 20 degree stub tooth will transmit 48 per cent more power than a 14½ degree standard tooth, for the same value of root stress.

The cost of manufacturing a gear or pinion of a given pitch diameter, face width, and diametral pitch, is not influenced by the choice of pressure angle.

From a noise standpoint, the 20 degree tooth is quieter for small numbers of teeth since there are more teeth in the arc of action. As the tooth numbers are increased, there should be no difference in the performance of either, from a noise standpoint.

In summing up the advantages which may be gained by choosing 20 degree stub teeth in preference to 14½ degree standard teeth, where the tooth numbers are low, the following desirable characteristics are restated:

1. The surface compressive stress was decreased.
2. The number of teeth in the arc of action was increased.
3. The beam strength of the teeth was increased.
4. There is no increase in the cost of manufacture.
5. From a noise standpoint the 20 degree stub tooth should result in a quieter combination for low tooth numbers.
6. Throughout this paper it has been assumed that the two types of gears discussed have been made to the same manufacturing tolerances.

DISCUSSION

PRESENTED BY

MYRON R. BOWERMAN, Alliance Machine Company, Alliance, Ohio

F. RICHARDZ, Manager, Gearing Engineering, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania

R. B. ZERFEY*, Chief Engineer, Tool Steel Gear and Pinion Company, Cincinnati, Ohio

D. R. MEIER, Transportation Motor Engineering Division, General Electric Company, Erie, Pennsylvania

A. A. VAN PELT, Norma-Hoffman Bearings Corporation, Pittsburgh, Pennsylvania

F. A. COMPTON, D-c Armored Motor Engineering Division, General Electric Company, Erie, Pennsylvania

L. J. COLLINS, Gear Engineering Division, General Electric Company, West Lynn, Massachusetts

C. W. VOKAC, Manager, Hydro-Arc Electric Furnace Section, Foundry Equipment Department, Whiting Corporation, Harvey, Illinois

*Deceased

Myron R. Bowerman: The 20 degree stub is undoubtedly much stronger than the 14½ degree, and it is only natural that engineers design these gears for greater loads. We have found that this tendency results in more rapid wear, on account of the greater tooth loads.

While the author states that the 20 degree stub is quieter in operation than the 14½ degree, we have found that in many cases the 20 degree has proved to be noisier. This may not be in accord with theoretical analysis. Also, in most cases which we have checked for noisy gears, we have found the main cause to be inaccurate tooth spacing.

Our problem in gearing is more a matter of wear than of strength. Our gear teeth do not break off, but they sometimes show a tendency to wear out. We try to design our pinions and gears with proper loads and of such materials, tolerances, and hardness that they will have long life. We like the 14½ degree outline. If the 20 degree outline is to be used, why not full depth rather than stub?

F. Richardz: It is very timely that this subject is presented at this time as it ties in with the contemplated revision of a proposed standard for selection of crane gearing and should be instrumental in clearing up a few questions that ordinarily arise during the formulation of a standard procedure.

In reference to the topic "Smoothness of Operation" where Mr. Collins states, "However, noisy gearing indicates that the tooth engagements are not smooth or that undesirable manufacturing errors exist," the undesirable manufacturing errors referred to, in my estimation, do not necessarily refer to the gearing alone, as quite frequently the manufacturing errors in regard to center distances of the gearing enclosure, such as out of parallelism, too close centers, or too wide centers, influence the sound level to a considerable extent. Also, center distance out of parallel may often be responsible for poor tooth contact, as well as occasional broken gear teeth. The gearing may be near perfect but poor mounting conditions can ruin them in a short time. Therefore, the mounting of the gears is an important item and should be given due consideration.

Mr. Collins has dealt primarily with 14½ degree pressure angle standard full depth tooth and 20 degree pressure angle stub tooth. It is admitted that the paper

primarily makes reference to low number of teeth and, therefore, the statements are exactly as outlined by Mr. Collins, but it would be well to bring out that the standard full depth 20 degree pressure angle tooth is and should be considered equally adaptable and in a number of ways preferred, especially where the number of teeth in the pinion exceeds 17, since for 17 teeth and up, no undercutting is required.

R. B. Zerfey: We are makers of hardened gears, which in most cases, are used to replace gears which have not given service as supplied on the original equipment.

We do not care if they are 14½, 20 degree full depth, 20 degree stub, or long and short addendum. We make them all to the customers' specifications, but through my thirty years of experience I have found that some tooth forms work out better than others. Of course, this is due in part to application. With the old crane gearing, that is, before ball bearing cranes were used, we found that the 14½ degree full depth tooth was the best tooth form to use. It took care of displaced centers, misalignment, and so forth, better than the 20 degree full depth or stub tooth.

I have noticed for heavily loaded gearing at fairly high speed, such as the drive gearing for diesel and electric locomotives with low-numbered teeth in the driving pinion, 20 degree full depth teeth are always employed.

I believe that a good bit of this changeover from 20 degree stub to 20 degree full depth was due to a noise condition, caused by the application required and low number of teeth in contact.

With extremely accurate gearing as to tooth spacing and profile, and rigid mounting, 20 degree stub teeth can be used with good results.

If you have a low number of teeth and have equipment, you can make the pinion long and the gear short addendum, either 14½ or 20 degree, whichever gives the best tooth proportion for ratio required.

You have strength, though not quite as great as a 20 degree stub, but taking all in all through my years of observation, for strength and durability I would suggest a 20 degree full depth tooth form.

I have said that a 14½ degree is absolutely necessary, with certain types of journal bearings. I have found on some Class "B" antifriction bearings, the stub tooth did not work so well, and although some gear engineers feel that pressure angle has nothing to do with bearing wear, it does have an effect.

I know from actual practice where sleeve bearings were used that we had to change from long and short addendum 20 degree back to standard 14½ degree teeth, and if necessary, for tooth strength to increase the pitch.

There are many arguments with reference to bearing pressures due to 20 degree pressure angle gears, but those are my observations on gears that I have actually seen in use, some of them operating for twenty years, with less bearing trouble due to the use of 14½ degree gearing.

Professor C. W. Ham of the University of Illinois performed a test a few years ago on a modified Lewis machine. They ran 14½ degree standard, 14½ degree long and short addendum, 20 degree tooth stub, and it did not prove anything conclusively on wear durability. Even though the theory may show that one is better than the other, this did not show in actual test.

D. R. Meier: This paper serves to emphasize the well known advantages of 20 degree pressure angle gearing over 14½ degree gearing. The 14½ degree system is very old, approximately 100 years old in this country. It is said that the angle of 14½ degrees was chosen originally because its sine is very nearly ¼, which enabled the patternmaker to more easily make a pattern for casting. The shortcomings of this system were long ago recognized, as is evidenced by the development of the so-called "variable center distance" system of 14½ degree gearing, in which the centers are arbitrarily increased to make the gears run at increased pressure angle.

The steady growth of power requirements of various types of industrial drives over the years has placed an ever increasing burden on the gears, until a stage has been reached where it is recognized that 14½ degree pressure angle gearing is unsuited to heavy duty power transmission. This is particularly true in the case of higher gear ratios, involving low numbers of pinion teeth.

There is little to be added to Mr. Collins' discussion of the technical aspects of this problem. However, it appears that Mr. Collins has understated the case for 20 degree gearing, rather than overstated it. Perhaps this was done in the interest of simplicity as well as conservatism. The example chosen for illustrative calculation, namely the 96/19 ratio, is more favorable to the 14½ degree gearing than some of the other ratios listed which have a smaller number of pinion teeth. This is indicated in some measure by Table IV, which lists contact ratios. For example, if a 76/15 ratio has been chosen to calculate bending stress, the point of worst application of load would have been at the tip of the tooth on the 14½ degree gearing, Figure 9, and in approximately the same location as now shown on the 20 degree tooth of Figure 10. The bending stress would of course have been higher on the 14½ degree tooth, and approximately the same as now shown on the 20 degree tooth.

In a set of gears having normal overlap in action, it is sufficiently accurate to calculate the compressive stress at the pitch point, as Mr. Collins has done. But when the number of teeth in action is very low, as is the case with the first three ratios listed for 14½ degree in Table IV, the load will be carried entirely on one tooth during a major part of the arc of action. During part of this period, the load will be applied at a point low on the tooth, where the radius of curvature is small. The compressive stress at this point will therefore be considerably higher than at the pitch point, and may be limiting.

While the comparison of contact ratios as given in Table IV shows the 14½ degree system to be at a bad disadvantage, it is probable that the actual values in operation are even more in favor of the 20 degree system, for 18 pinion teeth or less. The reason for this is that the small overlap in action on the 14½ degree gearing may be entirely destroyed by the slight errors in manufacture which are unavoidable even with the best manufacturing practice.

If an increase in pressure angle from 14½ to 20 degrees is advantageous, then it is pertinent to ask why

the pressure angle should not be further increased. In some cases, particularly in aircraft gearing in recent years, it has been found desirable to use pressure angles of 25 degrees or even 26½ degrees. However, these were special cases in which the high horsepower to be transmitted at high pitch line speeds made it desirable to use gearing in which the sliding action is very low. There are some disadvantages that begin to appear with higher pressure angles, particularly increased bearing loads, which would make it unwise to adopt a higher pressure angle for a whole line of gearing just to get an advantage on one end of a range of ratios.

In the field of railway gearing, 20 degree pressure angle was adopted as a standard about 20 years ago. Since its adoption it has had severe trials in many railroad applications, which are characterized by heavy loads, both static and dynamic, and at the same time by the necessity for almost unfailing reliability and long life. The results have proven beyond question the superiority of 20 degree gearing as compared to 14½ degree gearing. It is not unusual for a railroad to get a million miles of operation out of a set of gears in main line service. It may be said, without exaggeration, that most of the high powered, high speed electric and diesel-electric locomotives in this country could not have been built to give satisfactory gear life if it had been necessary to use 14½ degree gearing.

Problems regularly arise in the railway field in which, because of stringent space restrictions, no drive could be built if it were necessary to use 14½ degree gearing. These problems might also arise in the steel industry.

There is ample experience in the railway field and also in other industrial fields to demonstrate that the advantages enumerated by Mr. Collins for the 20 degree system have been realized in practice. In view of this experience, there is every reason to expect that the proposed 20 degree system will give greatly improved service in the steel mills.

A. A. Van Pelt: There is no question but what the pressure angle will increase the load on the bearings, that is, when you go from a 14½ to a 20 degree pressure angle, but the question comes up in my mind, why not use a bearing of sufficient capacity for the load?

R. B. Zerfey: That's right, but we have had some new designs where the gear is okay but they had to put in new roller bearings every year. This has been about fifteen years now, but they put in new bearings every year.

A. A. Van Pelt: Change to a roller bearing then.

R. B. Zerfey: We have and they should work. I would just like to ask the last gentleman a question. When he was talking about 20 degree teeth, was he saying "stub" or "standard" depth?

F. A. Compton: The experience that Mr. Meier referred to is with the 20 degree long and short addendum. The low wear and long life of railway gearing are accounted for by the pressure angle, as well as to the tooth form itself.

I might add something about the bearings. I do not believe that the high speed and bearing loads on the type you referred to are significant in this discussion because of the excess bearing capacity in steel mill auxiliary motors.

These motors have certain bearing capacities, and other lines being developed have still greater bearing capacity, which is enough greater to take care of that difference in bearing loads with 14½ and 20 degree pressure angles.

R. B. Zerfey: That is right. In Europe they used 14½ degree, long and short addendum, exclusively. They might be wrong, but some good things do come out of Europe. I have not been there to see how they do it, but it is said that to overcome the low number of teeth, they still use the 14½ degree form.

As for myself, I do not care but I do believe that to get the most wear and beam strength I would prefer the 20 degree tooth.

L. J. Collins: The first question was why not use the 20 degree standard?

In the particular division in which I am employed, we manufacture gearing for all types of applications. We might consider the gearing as coming in four groups.

There is the heavy spur gearing, as used by railway transportation, or such gearing as used by train people.

There is then the high-speed, precise reduction gearing where the loads are comparatively low, or have been in the past, and accuracy is the paramount feature.

Another type of gearing which is used is the gearing for calculating devices, such as gunfire control and gearing of that nature, which is a precise type of gearing as far as tooth-to-tooth spacing goes, but it is not necessarily a high-speed gearing. It makes only one revolution, maybe forward and back, or part of a revolution.

Then there is the fourth type of gearing, which is the type of gearing which we manufacture for the jet engines, where we have gearing which is extremely hard and infinitely accurate. That is, the tooth-to-tooth spacing is held to 0.00015 to 0.0002 inches maximum.

If you do turn to long and short addendum, 20 degree, as we do in the reduction gearing, you can evaluate that, due to your precise machining. It is possible in railway transportation gearing or crane gears to attain this same high precision, but the cost of that particular type of gearing may be prohibitive.

L. J. Collins: Mr. Bowerman states that in his experience designers realizing that the 20 degree stub tooth was stronger than the 14½ degree have increased the loading to a point where excessive wear resulted. The purpose of this paper was to show that for a given load and speed a gear made with 20 degree stub teeth would transmit more power without exceeding the stresses which would be imposed upon 14½ degree pressure angle teeth at a lower power rating.

We agree that in the majority of cases the main cause of noise is inaccuracies in tooth spacing. However, where the number of teeth on the pinion is limited, a 20 degree pressure angle tooth will result in more teeth in the arc of action, and hence smoother action.

Tooth wear can be attributed to a number of causes, dirt in the lubricant, no lubricant, faulty lubrication, or misalignment. The load is based upon psi compressive stress. If the same compressive stress is maintained, then the wear on two teeth of the same material and hardness should be the same.

Where precision gears are used, the advantages of employing 20 degree full depth, or long and short addendum, are employed. Where a high degree of

precision is not warranted the advantages of going to longer teeth may not be realized.

The errors in alignment and mounting referred to by Mr. Richardz in many cases are the cause of failures, either from wear or broken teeth. I agree that the 20 degree standard and full depth should be considered. The paper would have become quite lengthy, however, if all the factors I would have liked to have discussed were presented.

Mr. Meier has pointed out that the 96/19 ratio is more favorable to the 14½ degree gearing than some of the other ratios listed. This particular combination was chosen because of this fact. If under these conditions the 20 degree tooth is preferable, then it should follow that for the other combinations it is practically necessary.

C. W. Vokac: I listened to the discussions on the best pressure angle with a great deal of interest. Like most discussions at meetings such as this on a controversial issue, a listener at first-hand gets an impression of confusion from apparent conflicting reports and wonders who could be right. Actually, after a careful analysis of these apparently conflicting statements one finds them all correct.

As long as this is an electrical session and most of you are electrical engineers, let us compare a gear train with an electrical circuit and refer to it as a mechanical circuit for comparison. Without stretching one's imagination too far, the pressure angle is comparable to the power factor angle. The pressure angle divides the driving force vectorially into an active force which turns the gear and does the work and a reactive force which increases bearing pressures and does no useful work because it is 90 degrees out of phase with the direction of the work done.

The power factor angle, as you know, likewise divides the driving force vectorially into an active force which drives the current and does the work, and an inactive force which creates mechanical tension and pressure on the equipment in the circuit and does no work because it is 90 degrees out of phase with the direction of the current or the work done.

How did the electrical engineer solve his circuit problems? Does he choose the power factor angle or pressure angle and build his equipment around it? No, he tries to satisfy all the other conditions in the problem first and takes whatever angle results and hopes it will be low. He studies the load characteristics and the control equipment, and fills up the circuit with reactance enough to stabilize or quiet down the circuit to within acceptable limits. The added reactance increases the reactive force and decreases the active force. For a given power input, the power output is reduced and if the latter is insufficient, the input is increased and provision made in the circuit to handle it. This, of course, decreases the efficiency of the circuit but the solution of the problem is more important.

The mechanical engineer's problem perhaps can be solved following the same procedure. He could study his load characteristics which, as in the other case, vary with every application. From this study he will determine the magnitude of the reactive force he will need to quiet down his mechanical circuit and build his bearings to suit. For the work to be done, he can determine the magnitude of the active force required, and the two vectors will define the pressure angle best suited for that application. The angle may be compared with the standard angles for which the industry is tooled. If the angle is equal to or nearly 14½ degree, the equipment will operate satisfactorily, as at least one gentleman reported. If it compares with the 20 degree angle, it will function as the 20 degree group advocates. If it compares with neither, it may be economical to re-tool for some other angle as was done for the aviation industry.

One more comment needs be made. The electrical engineer can correct his error by simply moving to the next tap on the reactor.

EFFECT OF NOZZLE SIZE ON SURFACE QUALITY

By C. J. HUNTER, Chief Metallurgist
Carnegie-Illinois Steel Corporation, Gary, Indiana
(Abstract of paper presented before AIMME, Cincinnati, Ohio, April 23, 1947)

▲ IN an experiment, recently conducted at Carnegie-Illinois Steel Corporation's Gary steel works, to determine the effect on slab surface quality resulting from increasing pouring rates, a representative number of heats were made and poured through four nozzle sizes ranging from 2 in. to 4 in. in diameter. Most of these heats were teemed into 30 in. by 48 in. molds, but several 31 in. by 56 in. molds were included. The making and processing of these heats were followed by special observers who carefully recorded and classified the amount of conditioning required on each slab. In the case of rimmed steel surface removal ranges from 15 per cent for the heats poured through 2 in. nozzles to 2.4 per cent for those poured through 4 in. nozzles. The beneficial effects are nearly equally distributed between a reduction of scabs and breaks.

Times required to pour each ingot were averaged for each nozzle size and according to pouring sequence. Pouring time in each case included the time required to open the nozzle to a full stream and the time necessary to top off.

To determine how these characteristics affect slab surface quality, percentages of surface removal were averaged ingot by ingot in each of the four nozzle classifications. The pattern of scabs matches that of pouring time. While the pattern of breaks is more or less confined to a heat to heat match with pouring times, when superimposed on the scab pattern, the total surface removal matches very well with the pattern of pouring time. This would indicate that faster pouring has a beneficial effect on surface quality even on an ingot to ingot basis.

Additional confirmation of these results has been obtained from a similar experiment covering low carbon mechanically capped heats in a 2 in. to 3 in. nozzle range. As yet this experiment on mechanically capped steel has not been extended to cover the four inch nozzle size.

From these results it may be concluded that in a 2 in. to 4 in. range of nozzle sizes, slab surface quality on the grades studied improves as nozzle sizes and pouring speeds are increased when teeming into molds of comparatively large cross-sectional area.

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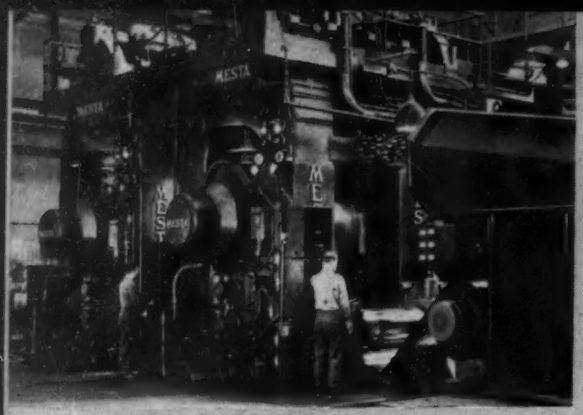

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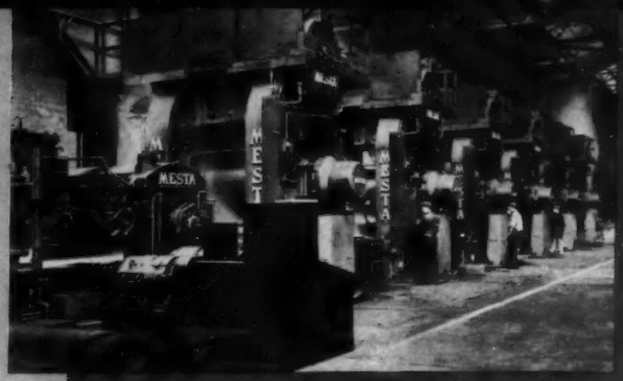

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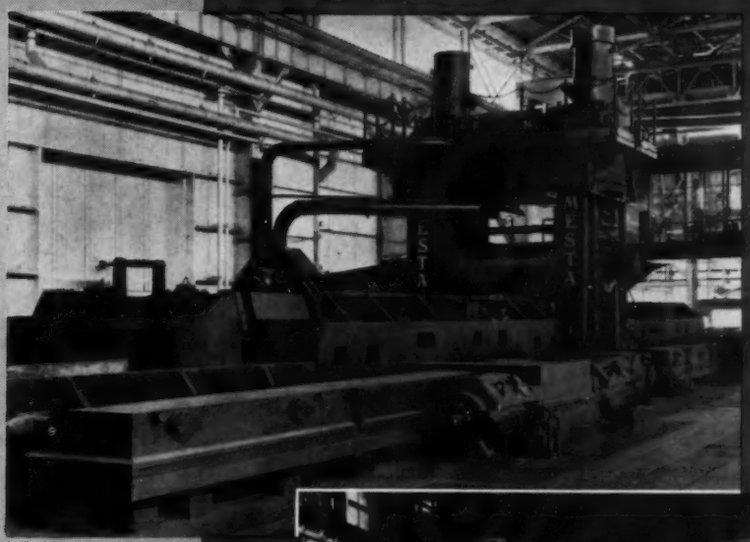

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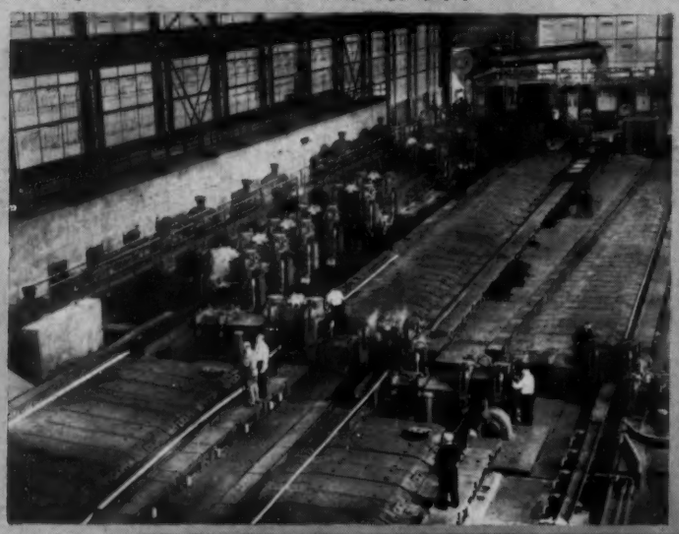

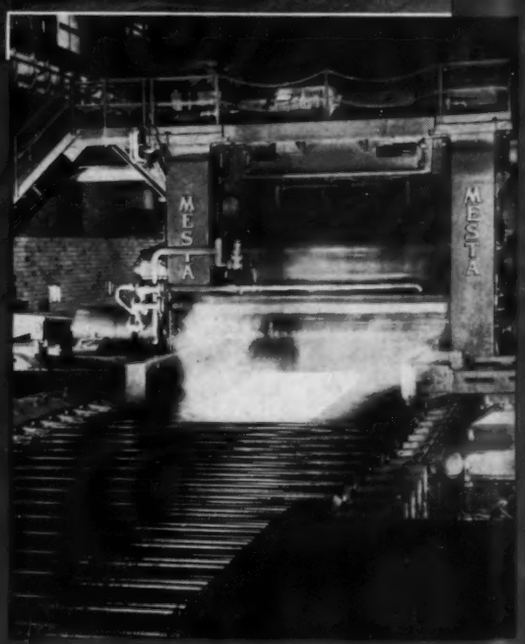

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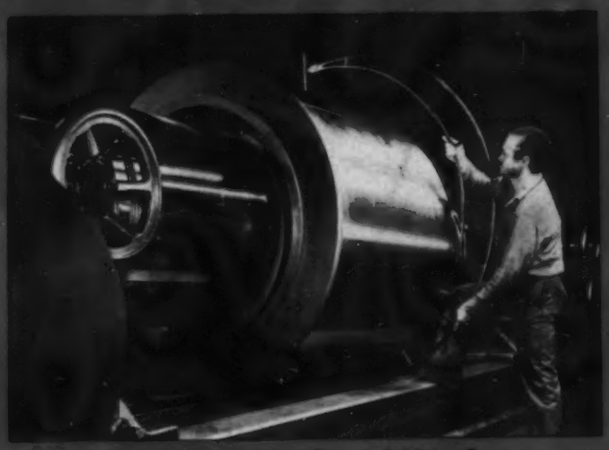

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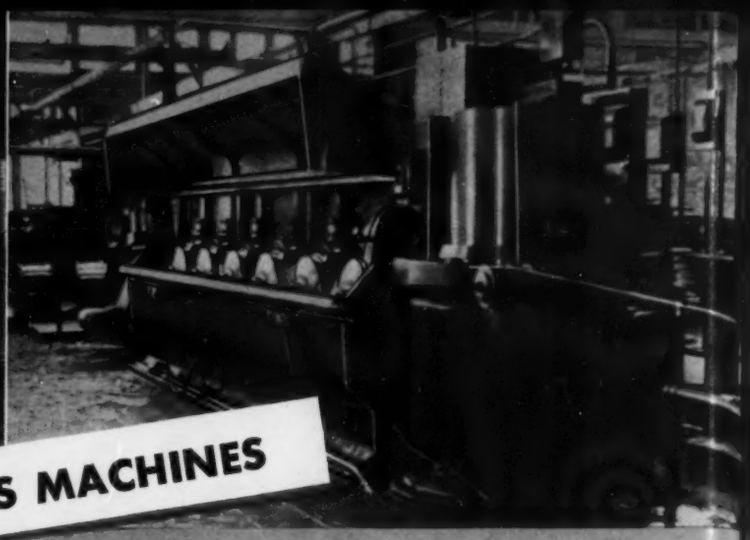

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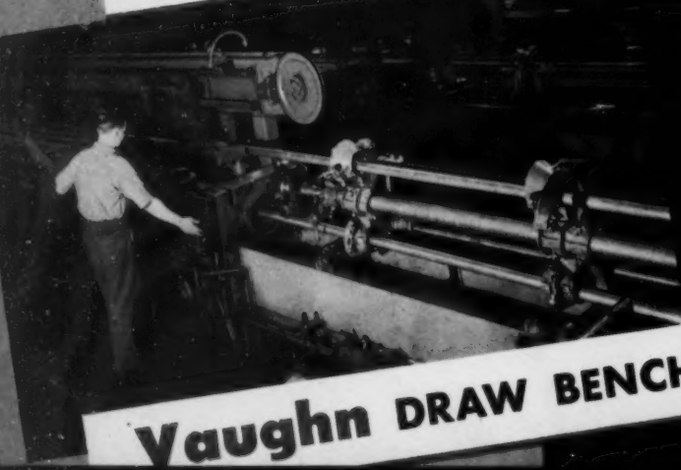

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—better metallurgical characteristics from speed and automatic process-control.
SAVINGS
—in processed metal, rejects, space, time, fuel, handling, straightening, pickling, quenching.
USED FOR
—through heating for heat treating, forging, extruding, upsetting; annealing; hardening followed by tempering; surface hardening and patterned, localized heating or heat-treating.
CONTINUOUS PRODUCTION
—for ferrous or non-ferrous bars, tubes, billets, strip, wire, castings, slugs or machined parts.
UNIFORM RESULTS
—by exact reproduction in continuous or repetitive operations.
COMFORT
—with ease and safety for the operator.
FLEXIBILITY
—in accommodating size-variety in one heating arrangement.
Connecting rod blanks heated for forging
Annealing in production line
Slug heating for forging
Through heating, surface heating or reheating of bars or tubing

The name Gradiation implies *radiation*—high speed, high temperature, solar-like heat; it implies *gradient*—faster heating by exposing metals to superheat with precise control of heating rate; it implies *gas-radiation*—which protects the charge and is economical to apply.

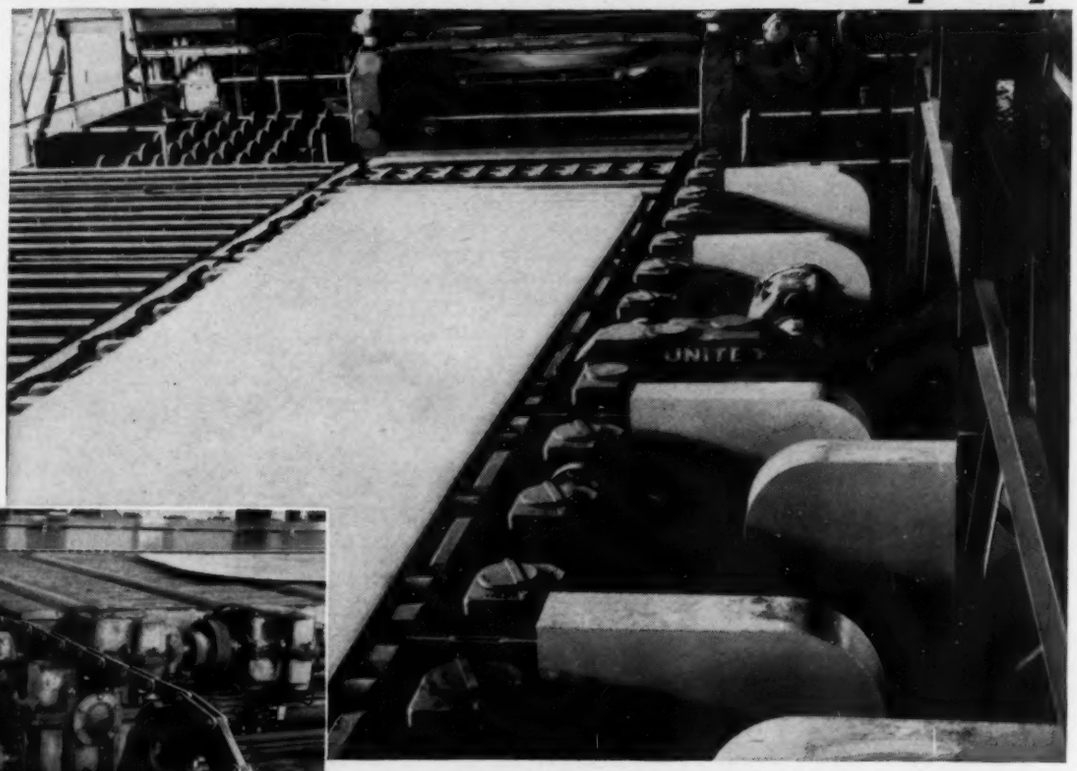
Gradiation is a development of Selas engineering. Whether your work with metals is producing or processing, ferrous or non-ferrous, send for the book. Ask of existing installations or of the adaptability of Gradiation to your work.

IMPROVED HEAT PROCESSING

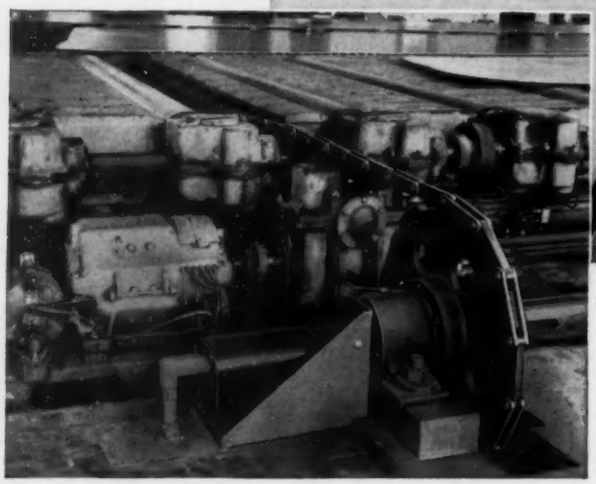
*SELAS TRADE NAME

SELAS CORPORATION OF AMERICA PHILA 34 PA

LINK-BELT TRANSFER CONVEYORS
Give *Precision Handling in the 120" Plate Mill at Lukens Steel Company*

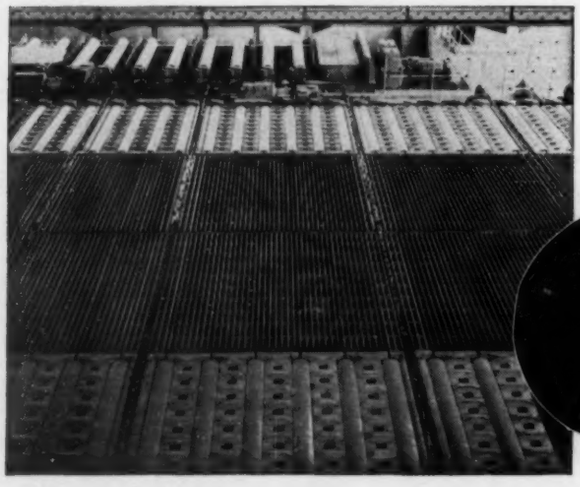


Pullover from cooling bed to leveller. Note precise alignment of plate edge with table.



Above—Transfer point where plate is removed from cooling bed to run-out tables by unloading conveyor.

Below—Transfer from one run-out table to another with provision for storage between Table No. 1 and Table No. 2.



For the new 120" Plate Mill at Lukens Steel Company, Coatesville, Pa., United Engineering and Foundry Co. selected Link-Belt Conveyors for handling plates in different stages of processing. Five are single units, the sixth is actually a combination of three units, as seen in the two smaller illustrations.

From broad experience in designing and building conveyors for every type of industry, Link-Belt engineers bring to current problems an unusual fund of knowledge, which, coupled with unsurpassed manufacturing facilities, assures their effective solution. Let Link-Belt conveyor and power transmission specialists aid you in making your operations more efficient—more economical.

LINK-BELT COMPANY

Chicago 9, Pittsburgh 19, Cleveland 13, Detroit 4, Indianapolis 6, St. Louis 1, Kansas City 6, Mo., Philadelphia 40, Atlanta, Dallas 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8.
Offices in Principal Cities.

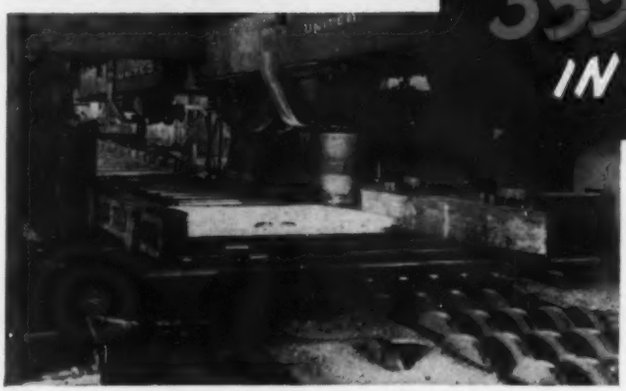
10.295

LINK-BELT CONVEYORS

PREPARATION EQUIPMENT . . . POWER TRANSMISSION MACHINERY

United 120" Plate Mill at Lukens Steel Company.

355 TIMKEN BEARINGS IN MAJOR EQUIPMENT



United Vertical Edger for 120" Plate Mill.

McKay 14" Leveler.

help to keep things rolling in the 120" mill at Lukens . . .

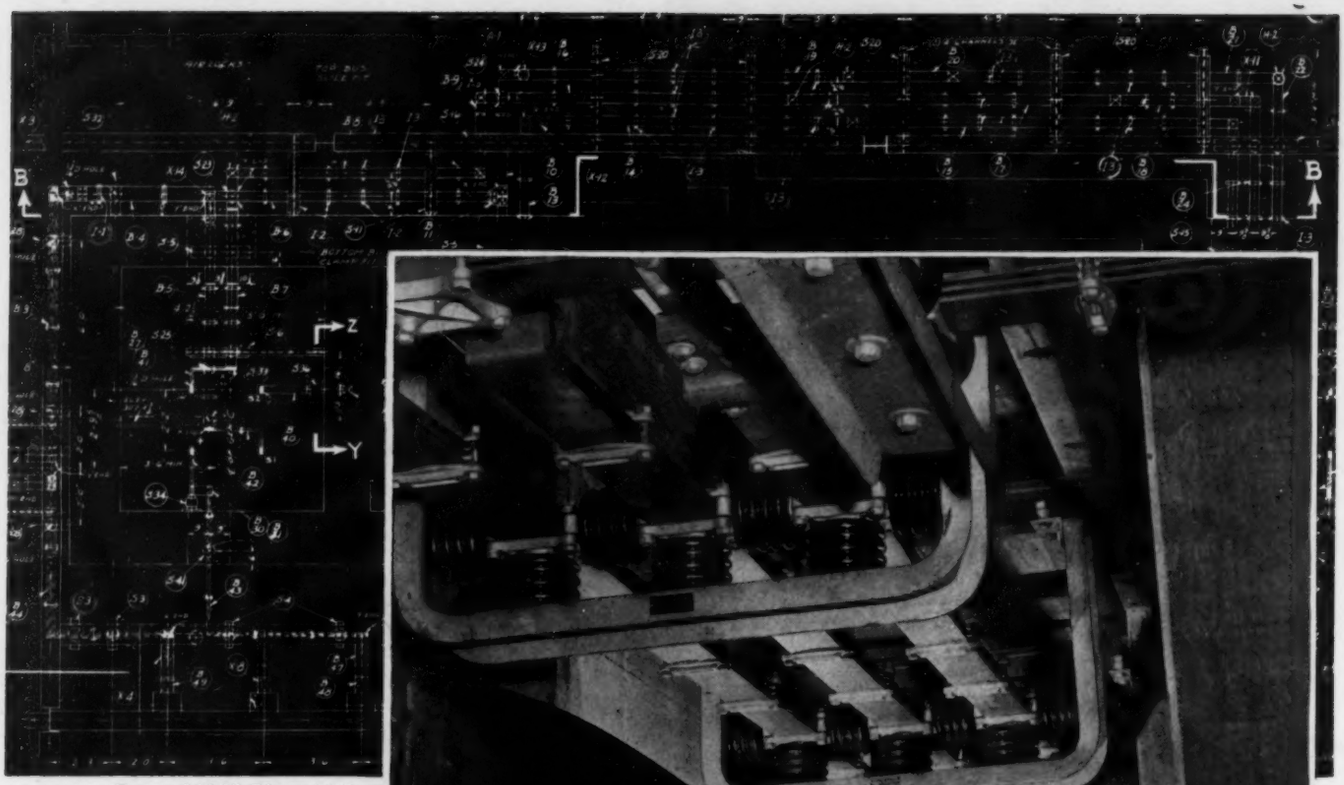
Timken Tapered Roller Bearings are engaged in virtually every steel processing operation in the 120" mill at Lukens Steel Company.

Following is a list of the various kinds of main and auxiliary equipment in which Timken Bearings are applied, with the number of bearings used in each case.

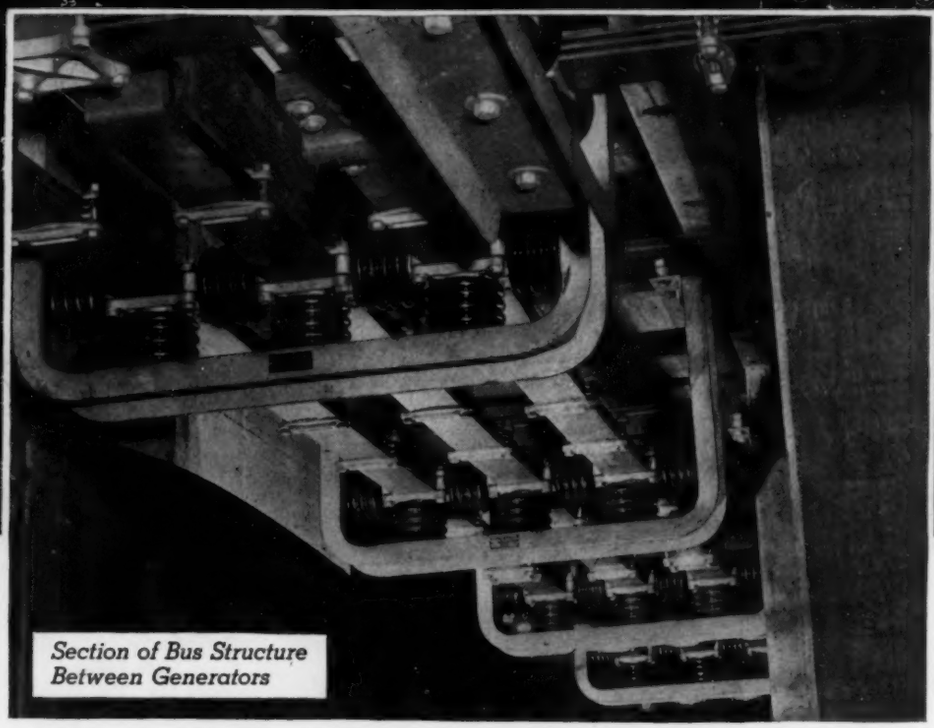
Ingot Car	10 Timken Bearings
Receiving Table	7 " "
112" Mill Edger Approach Table	9 " "
112" Edger Delivery Table	12 " "
42" Vertical Edger	6 " "
112" Intermediate Table	18 " "
120" Mill Front Table "A"	26 " "
120" Mill Back Table "B"	23 " "
120" Mill Attached Vertical Edger	13 " "
120" Mill — Work Roll	4 " "
120" Mill — Screwdown	10 " "
Backup Roll Changing Rig	6 " "
McKay 10" Levelers	36 " "
Ducking Dog Table "J"	5 " "
McKay 8" Leveler	40 " "
120" Mill Transfer Table "T-5"	7 " "
120" Mill Transfer Table "T-2"	14 " "
Plate Centering Device "F" Indicators	8 " "
McKay 14" Leveler	32 " "
120" Mill Transfer Table "T-3"	30 " "
156" Vertical Shear	15 " "
Rotary Shear Drive	4 " "
Rotary Shear Traverse	4 " "
Scrap Chopper Drive	8 " "
Adjustable Side Guards Table "W-2"	2 " "
Plate Centering Device Table "2"	6 " "
	355

TIMKEN
TRADE-MARK REG. U. S. PAT. OFF.
TAPERED ROLLER BEARINGS

THE TIMKEN ROLLER BEARING COMPANY, CANTON 6, OHIO



Part of 120" Plate Mill Main Bus Structure



Section of Bus Structure Between Generators

PROTECT AGAINST SHORT CIRCUIT DAMAGE

INSTALL DELTA-STAR REINFORCED BUS STRUCTURES FURNISHED COMPLETE FOR HEAVY DUTY MILL SERVICE

Bus structures must be able to withstand the terrific forces generated in the event of a short circuit. No present day circuit breaker is capable of opening within short enough time to protect the bus. Short circuits are disastrous when bus failures occur. By installing an adequately strong structure you reduce this hazard to a minimum.

On your next installation be protected. Install Delta-Star prefabricated reinforced bus structures designed and furnished complete to the last detail. Highest quality wet process porcelain, heavy steel frames and careful engineering assure a structure that will withstand the stress.

Delta-Star has been designing bus structures for heavy duty steel mill service in close cooperation with customers' engineers for over thirty years. Their long successful record is outstanding evidence why steel mill engineers prefer Delta-Star equipment.

Prefabricated bus structures are available for bar, tubing, structural or special shapes; indoor or outdoor service. *Ask For Publication 4504.*

DELTA-STAR ELECTRIC COMPANY

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NEW YORK OFFICE — 140 Cedar St., New York 6, N. Y.

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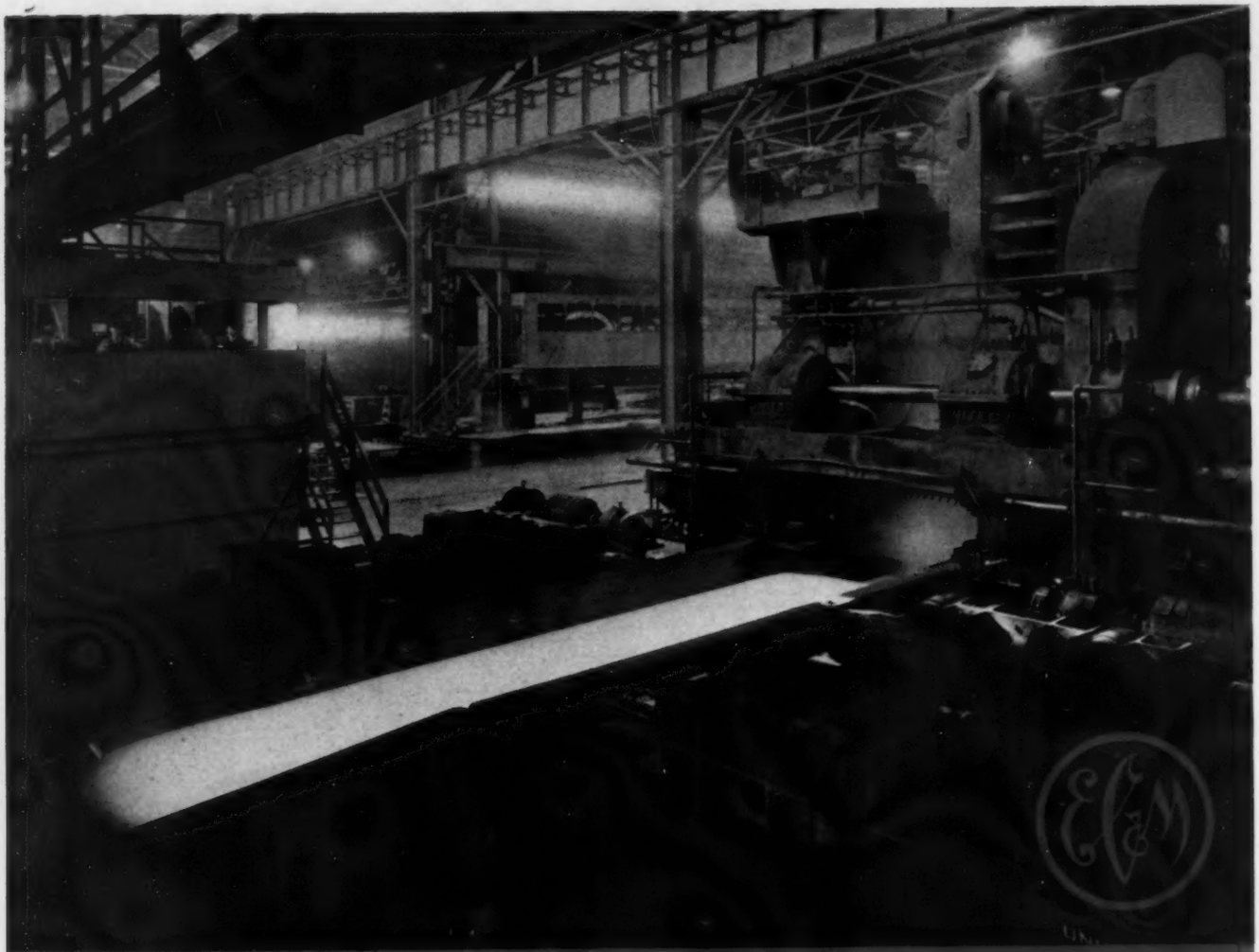
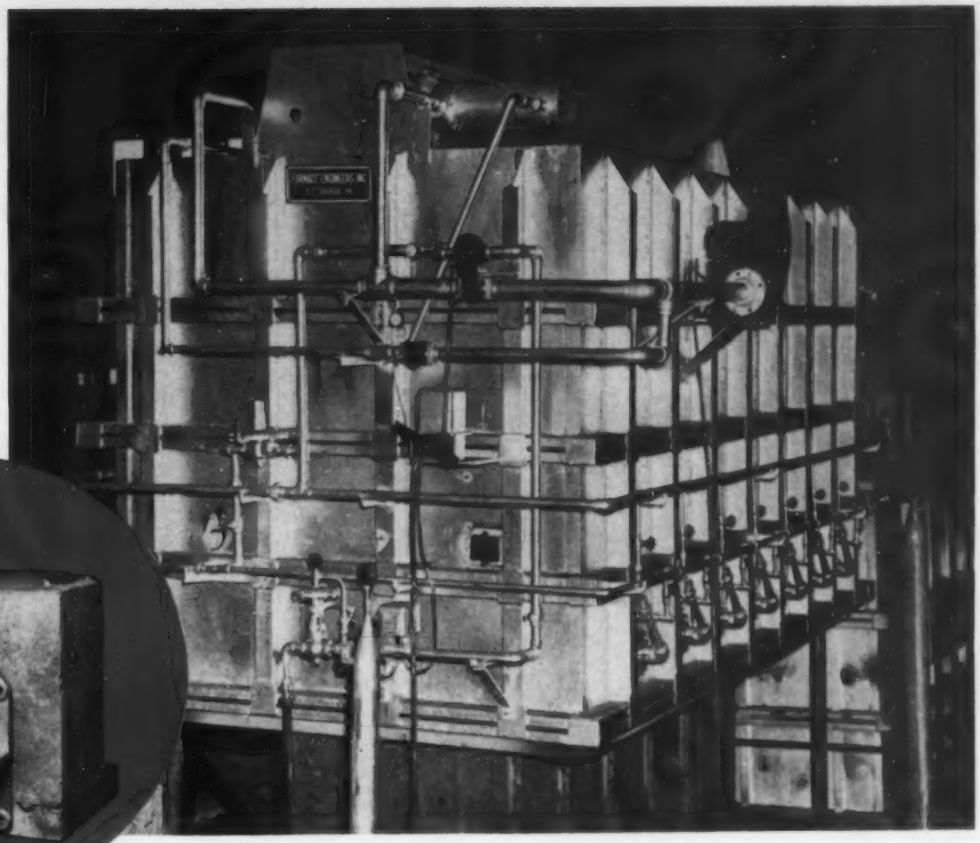


Pre-Set Rolling of Plates With EC&M Automatic Screwdown Control. Screwdowns, edgers, and sideguards move to exact rolling dimensions automatically under single push-button operation. Operator is stationed in enclosed, elevated pulpit with clear view of all operations in this large, 120-inch plate mill. This simple EC&M control is used in several mills throughout the United States, resulting in improved product, faster rolling with extreme accuracy.

Like An Organ Player, The Operator Rolls Steel from button-panel using schedule No. 1 while an assistant prepares schedule No. 2 for a change in rolling requirements.

Also In This Same Plant Is The World's Largest Plate Mill (shown above). It has been EC&M controlled for many years.

THE ELECTRIC CONTROLLER & MANUFACTURING COMPANY, 2698 East 79th St., Cleveland 4, Ohio



A typical F.E.I. burner assembly. Sturdy, easily controlled, engineered for the job.

Accurate, Economical PRODUCTION

With F.E.I. *Patented Combustion System*

F.E.I. EQUIPMENT

- Direct-Fired Cover Furnaces for annealing, spheroidizing, Normalizing and Bright annealing of wire, rods, coiled strip, flat sheets and tin plate.
- For Heavy Coil Loads: Patented Convection Base, gives 2 to 4 times longer service.
- For Wire, Bar and Tube Mills: Galvanizing, patenting and Normalizing furnaces.
- For Pipe, Sheet, and Job Plants: Hot Dip Galvanizing Furnaces.
- Car Type Furnaces, Rod Heating, Lead Quenching, Ladle Heating and Salt Bath Descaling Furnaces.
- Continuous Quenching and Tempering Furnaces—Quench Tanks, Water or Oil.
- Soaking Pits.

Accurate heat-treating can only be accomplished with accurate heat. You are assured of the kind of heat you need when your furnace is designed by Furnace Engineers, with particular attention being given the heat producing elements through F.E.I.'s patented combustion system. Performance records prove that you get flexible, controllable heat with minimum maintenance costs from F.E.I. furnaces.

F.E.I.

FURNACE ENGINEERS, *Inc.*

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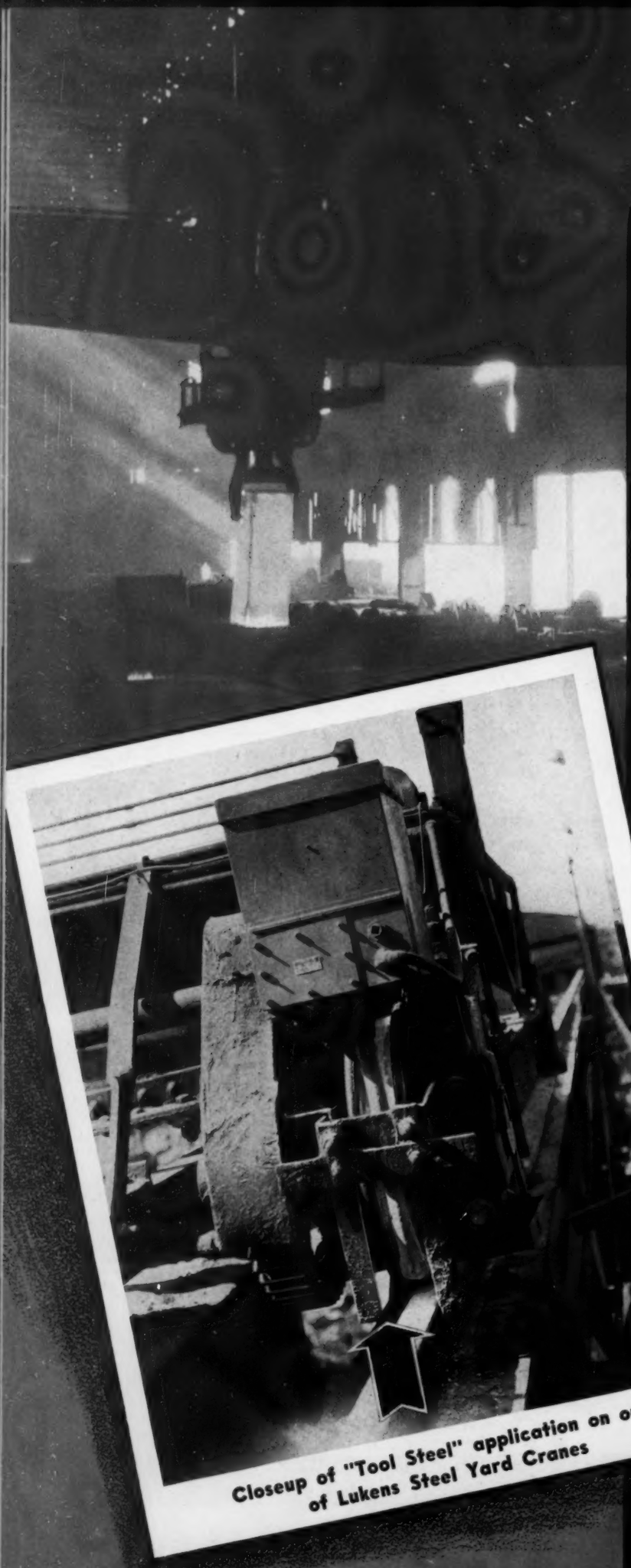
1551 WEST LIBERTY AVENUE ★ PITTSBURGH, PA.



Closeup of "Tool Steel" application on one of Lukens Steel Yard Cranes

"TOOL STEEL" PROCESS CRANE PARTS

including

TRACK WHEELS • GEARS
PINIONS • BRAKE WHEELS
SHEAVES • PINS • DRUMS

do give ***longer*** service. That's one reason why Lukens Steel Company uses "TOOL STEEL" PROCESS hardened products.

• • • •

"TOOL STEEL" PROCESS

GEARS • PINIONS • ROLLS
WHEELS • SHEAVES
SCREWDOWN SCREWS
AND NUTS

and other hardened products are doing record-breaking jobs in all departments of the steel industry.

THE TOOL STEEL GEAR & PINION COMPANY

CINCINNATI 16, OHIO

"Round table" approach to Rolling Mill design

Putting a customer's rolling mill problem before a group of experienced engineers for detailed analysis is Bliss' way of bringing an operating need into sharp focus.

The end results take shape in some of the country's outstanding sheet and strip mill installations. Bliss designs and builds for year-in and year-out efficiency.

Two-, three-, or four-high mills for hot and cold rolling, single stand, reversing or tandem operation, are built by Bliss for ferrous or non-ferrous application. In addition, Bliss builds cluster mills and a variety of accessory mill equipment, including mandrel type hot mill coilers, upcoilers, slitters, reels, etc.

Leading companies — here and abroad — have boosted output and cut costs with Bliss mills and accessories. Discuss your current rolling mill problem with Bliss. There's no obligation for prompt and constructive appraisal of your needs.

E. W. BLISS COMPANY

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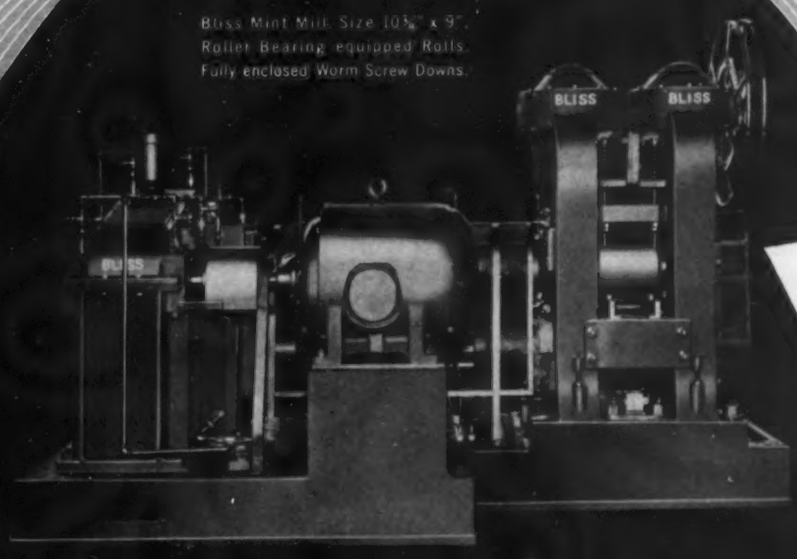

Bliss Mint Mill. Size 10¾" x 9". Roller Bearing equipped Rolls. Fully enclosed Worm Screw Downs.

STAY AHEAD WITH *Bliss*

rolling mills
mechanical and hydraulic presses
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1847 1947
A CENTURY OF SERVICE to Industry THAT MADE America Great

WE WERE HERE WHEN MILWAUKEE WAS SPELLED M-I-L-W-A-U-K-I-E!

MILWAUKIE, 1847 — A frontier settlement celebrates its first birthday . . . and a small factory turns out its first product—*millstones.*

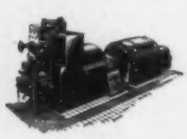
One-hundred years later, in 1947, this progressive city salutes its oldest heavy machinery manufacturer—Allis-Chalmers . . . *one of the Big 3 in electric power equipment—biggest of all in range of industrial products!* Today, practically every U. S. manufactured product is aided in its course by Allis-Chalmers equipment.

In building a *better* millstone, crusher, turbine, motor—Allis-Chalmers has earned the respect and confidence of men in every industry.

We are proud to serve this basic pattern of American life: Power and Electrical — Mining and Rock Processing—Ferrous and Non-Ferrous Metal Producing — Metal Working — Food — Textile — Chemical — Petroleum — Wood — Rubber — General Manufacturing — Transportation — Construction — Public Works — Agriculture — National Defense. ALLIS-CHALMERS, MILWAUKEE 1, WISCONSIN.

ALLIS-CHALMERS

One of the Big 3 in Electric Power Equipment
Biggest of All in Range of Industrial Products

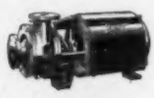


Power Generation . . .

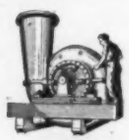
Electrical Distribution . . .

. . . and Control Equipment

Texrope V-Belt Drives



Centrifugal Pumps



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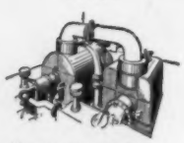

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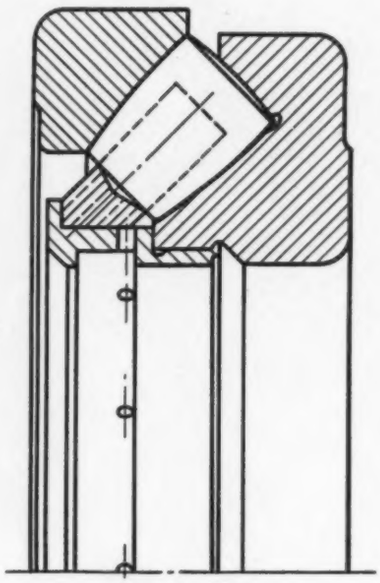
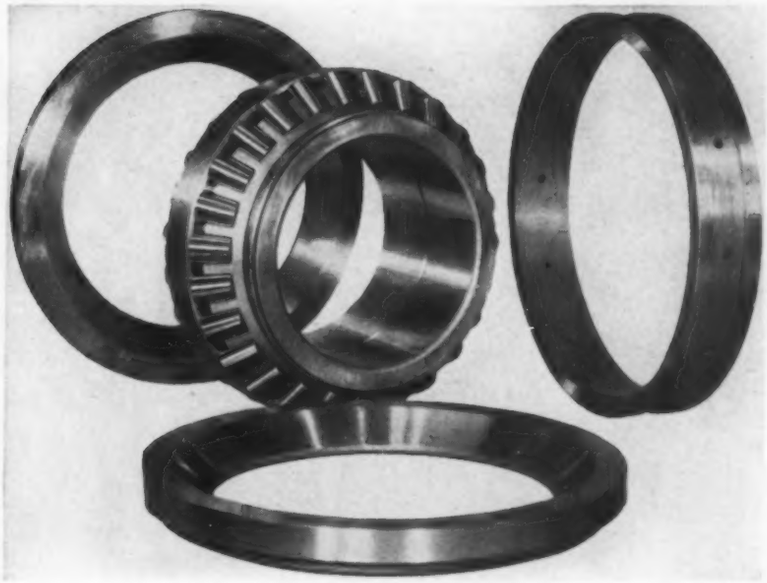
For Heavy Thrust Loads High Speeds!



● *Standardized* **SKF** *Spherical Roller Thrust Bearing*



● *Double directional adaptation for 4-High Back-up Rolls*

SKF Spherical Roller Thrust Bearings are designed not only for the back-up rolls of 4-High Mills, but for all severe duty applications such as worm thrust locations in screwdowns and large speed reducer units, turntables, huge high-speed pumps, etc. Complete series of this bearing have been developed, and many sizes are available. See your nearest **SKF** representative, or write direct. 6244-A

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PREFERRED

SKF

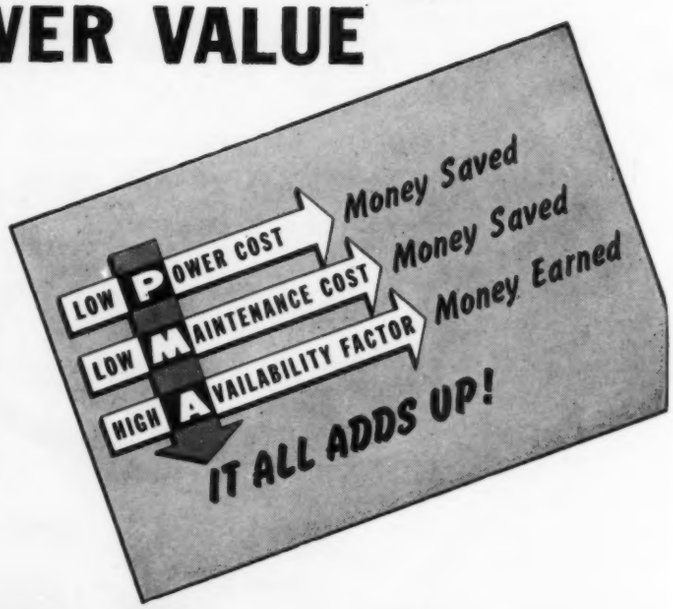
Spherical Roller Thrust Bearings

This adds up to

REAL TURBO-BLOWER VALUE

Of course, investigation of design features, construction details and materials will tell you the inside story of a turbo-blower, but the real measure of blower value is its record of low Power costs, low Maintenance costs and high Availability. This is value measured in dollars and cents . . . money you won't have to spend.

Looking at it this way, every Ingersoll-Rand turbo-blower (and we've built a lot of them) has proven its value with an excellent P-M-A record.



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Mass Lubrication for Mass Production

A Few of the Hundreds of Machines Now Equipped with LINCOLN Centro-Matic Lubricating Systems...

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- ☐ Back Geared Presses
- ☐ Brake Presses
- ☐ Blast Furnaces
- ☐ Cranes
- ☐ Crimpers
- ☐ Centerless Grinders
- ☐ Candy Machinery
- ☐ Cutters
- ☐ Chemical Machinery
- ☐ Cold Roll Mills
- ☐ Conveyors
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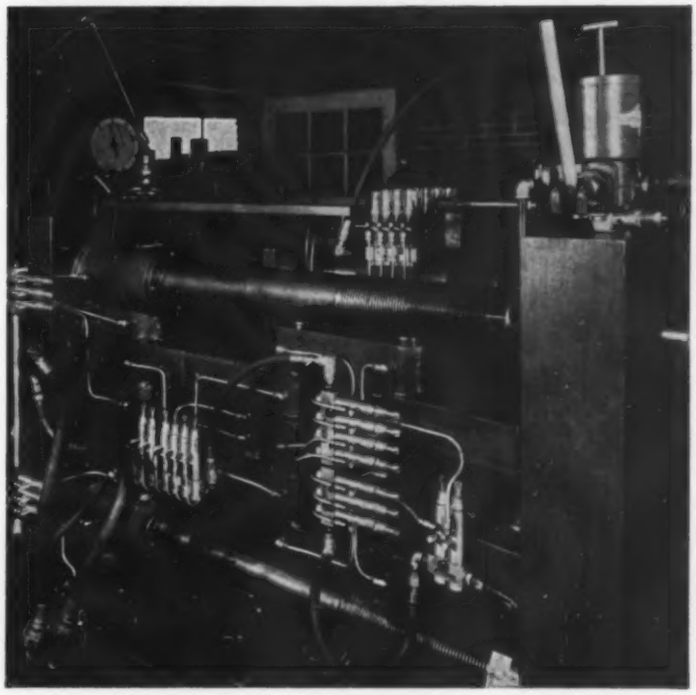
- ☐ Chip Stokers
- ☐ Crushers
- ☐ Caramel Cutters
- ☐ Cookers
- ☐ Coilers
- ☐ Dry Presses
- ☐ Drying Machines
- ☐ Duplicators
- ☐ Die Casters
- ☐ Draw Benches
- ☐ Electric Shovels
- ☐ Forging Machines
- ☐ Forming Presses
- ☐ Filter Presses
- ☐ Filtering Equipment
- ☐ Grain Presses
- ☐ Grinders
- ☐ Hydraulic Presses
- ☐ Lathes
- ☐ Locomotives
- ☐ Mixers
- ☐ Mine Tipples
- ☐ Metal Reclaimers
- ☐ Pasting Machinery
- ☐ Punch Presses
- ☐ Printing Presses
- ☐ Plastic Presses
- ☐ Processing Machinery
- ☐ Packaging Machinery
- ☐ Plate Shears
- ☐ Rubber Mills
- ☐ Rolling Mills
- ☐ Roll Squeezers
- ☐ Separators
- ☐ Steam Shovels
- ☐ Spacing Machines
- ☐ Starch Bucks
- ☐ Screw Conveyors
- ☐ Slab Mills
- ☐ Shears
- ☐ Tube Coiling Machinery
- ☐ Tow Boats
- ☐ Tin Plate Machines
- ☐ Veneer Dryers
- ☐ Wall Board Machines

847-5

LINCOLN
CENTRO-MATIC LUBRICATING SYSTEMS

Save Bearings, Machine Hours, Man Hours, Power... and Prevent Accidents with these outstanding Single-Line Lubricating Systems. They assure positive lubrication with a metered quantity of lubricant to every bearing... No "hit or miss" methods. They are easy to install on new or old machines. Lincoln Centro-Matic Systems consist of a number of injectors—one for each bearing, a lubricant pump and a single lubricant supply line from the pump to the injectors. The pump can be time clock or push-button controlled, power operated, or manually operated. One lubricant pump can supply lubricant for a single machine or a battery of machines.



A difficult lubrication problem on a die casting machine solved by a Lincoln Centro-Matic Lubricating System. No more overlooked bearings. Hand-operated pump supplies lubricant through injectors to all bearings which are connected by tubing and flexible high-pressure hose.

Engineering Service...

Our lubrication engineers are ready to assist you in solving your lubrication problems and help you reduce maintenance overhead. We invite you to make use of this service which is offered without obligation.

LINCOLN ENGINEERING COMPANY
5701 NATURAL BRIDGE AVE., ST. LOUIS 20, MISSOURI

Iron and Steel

IN THE

PHILADELPHIA DISTRICT

BY T. J. ESS

. . . . one of the important iron and steel producing regions of the country is the area covered by the Philadelphia district section of the Association of Iron and Steel Engineers. . . . this area is one which may become even more important as shortages of lake ores necessitate the importation of foreign ores . . . .

▲ ALTHOUGH not usually thought of as a steel center, the area around Philadelphia within a radius of approximately 150 miles contains between 11 and 12 per cent of the total ingot capacity of the United States. In this area are 21 blast furnaces with an annual capacity of 6,350,090 net tons, 133 open hearth furnaces with a capacity of 10,105,890 net tons per year, three bessemer converters of 240,000 net tons per year capacity, 41 electric furnaces totaling 640,420 net tons annual capacity, and one crucible furnace.

Finished product capacity of the district is as set forth in Table I. It will be noted from this table that, in comparison with the entire industry, the district is proportionately high in its capacity for plates, structural shapes, tool steel bars, lap weld pipe, and bolts, nuts, rivets and washers, and is low in hot and cold rolled sheets and strip, seamless tubes, and hot rolled and cold finished bars.

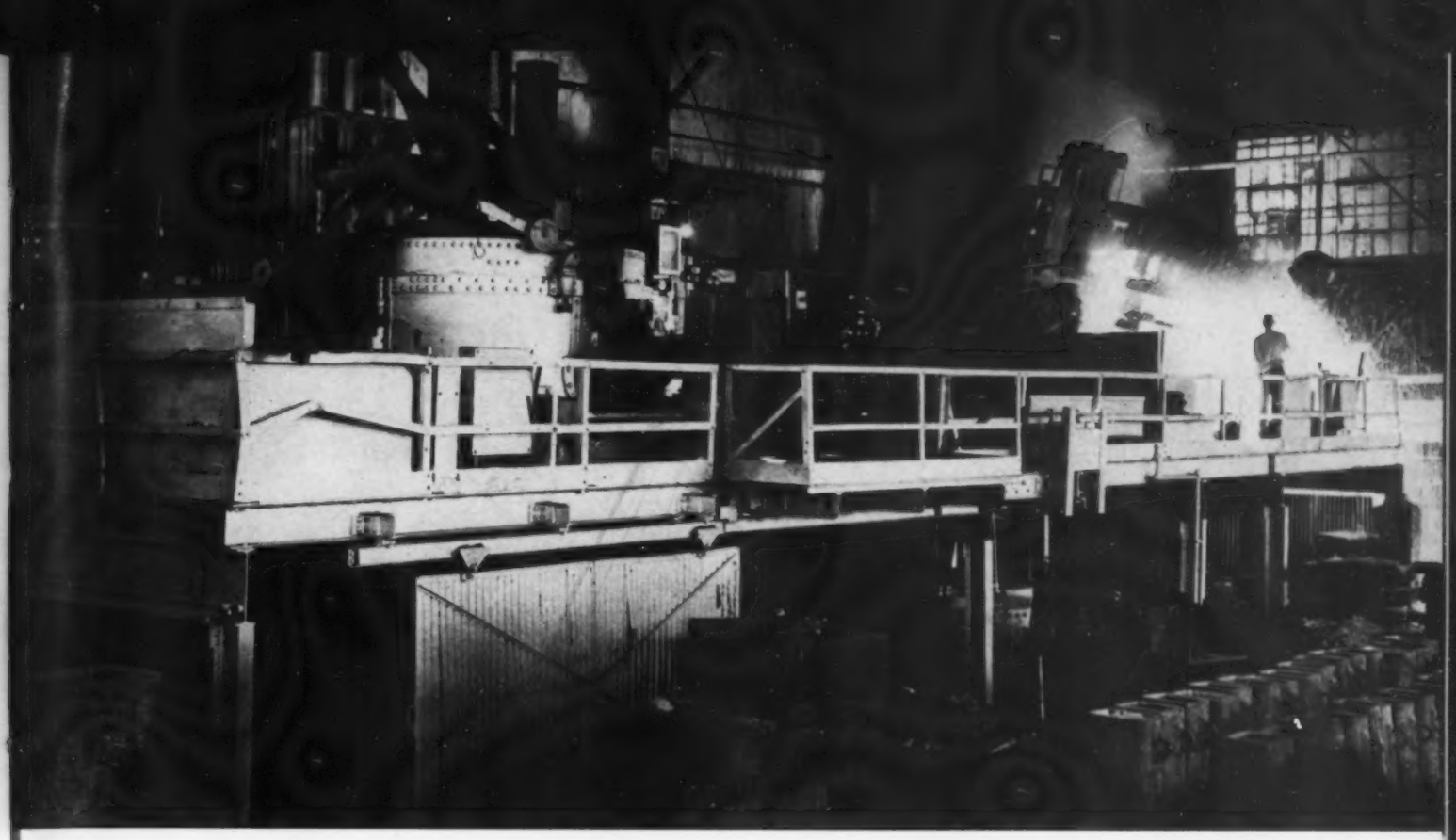
The first iron works in America was established by the Virginia Company in 1619 at Falling Creek, Virginia, 66 miles above Jamestown. This forge was built by John Berkeley, and operated only until 1622, when it was destroyed by Indians. About 1682, an iron works was built by Henry Leonard of Massachusetts,

TABLE I

FINISHED PRODUCT CAPACITY

Philadelphia District

	Annual capacity, net tons	Per cent of Total U. S. capacity
Structural shapes	1,784,000	19.5
Steel piling	36,000	8.2
Plates, sheared	1,802,460	22.6
Plates, universal	425,600	19.2
Plates, strip mill	50,000	7.7
Plates, flanged and dished	16,000	....
Rails	580,000	14.4
Splice bars and tie plates	160,000	8.6
Track spikes	36,000	9.9
Frogs, switches and trackwork	54,000	....
Wheels, tires, rings, springs, etc.	119,230	....
Hot rolled bars (except tool steel)	1,470,330	6.4
Concrete reinforcing bars (included above)	200,000	2.9
Tool steel bars	59,500	20.8
Cold finished bars	168,550	5.3
Skelp	600,000	3.2
Pipe, butt weld	301,470	13.3
Pipe, lap weld	228,000	24.9
Pipe, galvanized	200,000	....
Pipe, couplings	2,000	....
Cold drawn seamless tubing	10,900	....
Wire rods	672,480	9.2
Wire, plain	483,130	8.2
Wire, galvanized	151,500	8.8
Wire nails and staples	79,400	6.3
Wire, barbed	14,400	2.6
Wire bale ties	9,800	7.0
Wire, rope and strand	59,700	....
Black plate, chemically treated	74,000	18.6
Tin and terne plate, hot dipped	600,000	16.0
Tin and terne plate, electrolytic	216,000	9.8
Sheets, hot rolled	775,000	4.5
Sheets, cold rolled	58,000	0.8
Sheets, galvanized	240,000	8.4
Hot rolled strip	17,000	0.2
Cold rolled strip	69,600	1.9
Strip, galvanized	10,000	0.3
Bolts, nuts, rivets, washers, etc.	106,400	23.5
Forgings	513,930	....
Steel castings	75,840	....
Iron castings	197,000	....



Two electric furnaces at Henry Disston and Sons Company produce steels of special analyses and high quality, which are then worked into a number of specialties.

located at Tinton Falls, near Shrewsbury, New Jersey. Conditions in New Jersey were quite favorable to the manufacture of iron because of deposits of rich magnetic ore, coupled with wooded hills and mountain streams. At the end of the 17th century, New Jersey and Massachusetts were the principal producers of iron.

In 1692 iron manufacture was begun in Pennsylvania. Throughout the 18th century, additional works were built in Pennsylvania, New Jersey and Maryland. The early works were of the forge and bloomery type with blast furnaces beginning the production of pig iron somewhat later.

These bloomeries consisted of a hearth type furnace, rectangular in shape, about 3 ft × 2 ft, with a stack to carry off waste gases. They were generally open in front, like an open fire place. Blast was introduced through a tuyere some 20 in. above the bottom. In their advanced stages of development, blast was supplied by a bellows operated by a water wheel or steam engine, and the blast was heated by passing air around cast-iron pipes through which hot gases passed from the furnace to the stack. Charcoal was first put on the hearth, the blast turned on, and when the fire was burning well, ore was spread on the charcoal. Alternate layers of charcoal and ore were added until a sufficient amount of metal had collected on the bottom. This iron, a pasty mass containing much slag, was then removed from beneath the fuel bed and hammered into a bloom. Some iron was produced by this method as late as 1901.

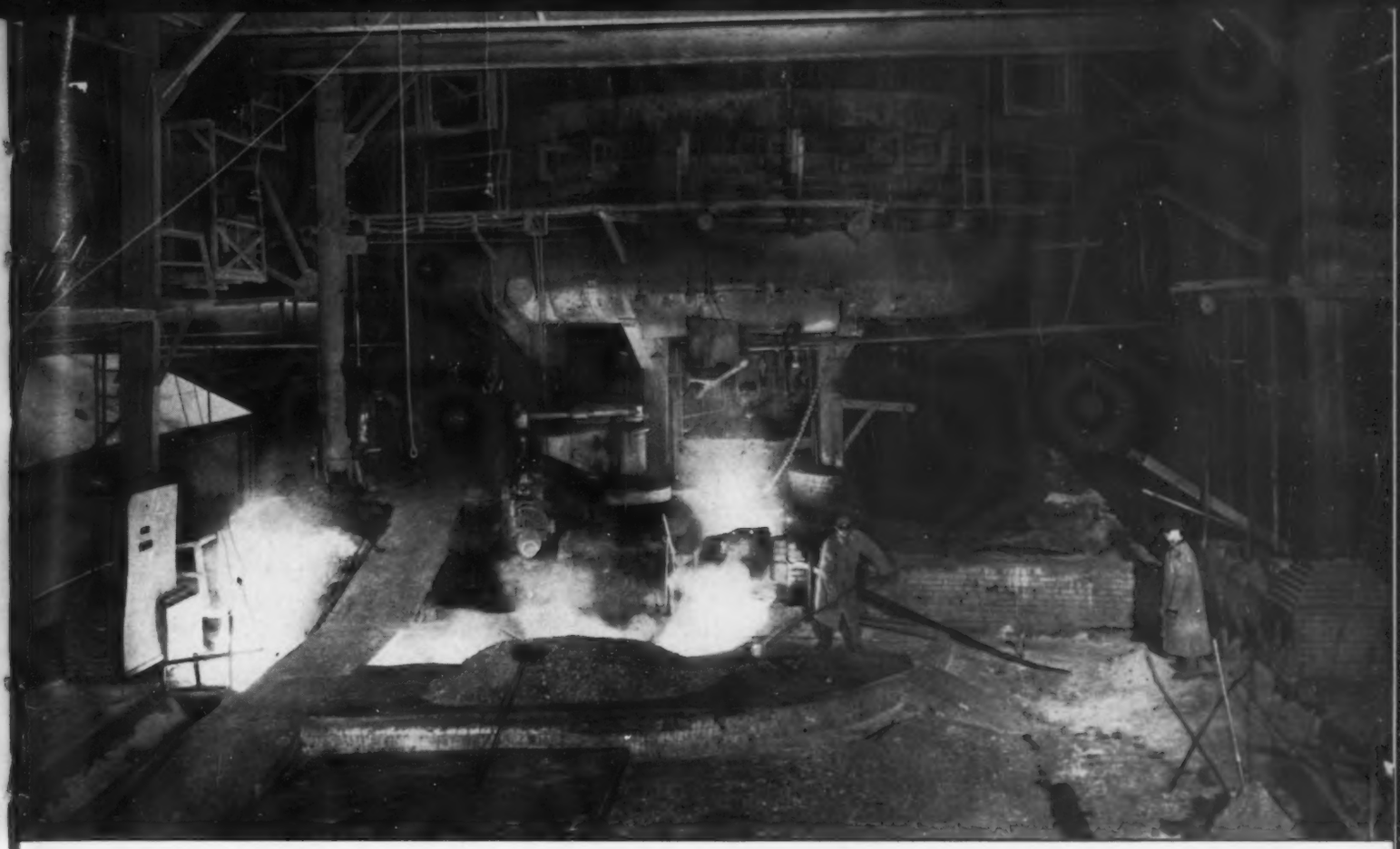
Early blast furnaces usually consisted of masonry truncated pyramids, 20-30 ft high, containing a circular shaft about 4 ft in diameter at the top and about 8 ft at the bosh. Ore, flux and charcoal were charged into the top of the furnace, while air at low pressure was blown in at the bottom. Such furnaces turned out one to six tons per day. Even as late as 1880, blast furnace output averaged somewhat less than 100 tons per day.

Among the early works in the Philadelphia territory were a forge erected on Manatawny Creek in Berks County about 1716, and another, known as Coventry forge on French Creek in Chester County. The latter works was still active in 1856, making blooms from pig iron. Around 1720, Colebrookdale furnace was built on Ironstone Creek, north of Pottstown, in Berks County. The pioneer iron enterprise in Maryland was probably a bloomery built about 1715 at North East in Cecil County.

Durham, on Durham Creek in Bucks County, was the site of considerable early iron working activity. The first furnace which was built there in 1727 made pig iron to be converted into bar iron, and remained active until 1791. In 1848 and 1851 two furnaces were built there, using anthracite coal as fuel. These units were torn down in 1874 and replaced by a larger blast furnace.

Other early works that might be mentioned are the Glasgow forge near Pottstown, Spring forge in Berks County, Green Lane forge above Norristown, Pine forge and Mount Pleasant forge above Pottstown, Olney forge on Manatawny Creek, and Reading and Warwick furnaces on French Creek. This latter furnace cast many cannons and cannon balls for the Continental Army during the revolution, and remained in operation until 1867. The Mount Joy forge at the mouth of East

Warwick furnace (top left) was built in 1737 near Pottstown, and produced as much as 40 tons of iron per week. Water wheels, such as that at Hopewell furnace (top right), provided power for blowing early furnaces. Water power also drove iron working equipment, such as the hammer at Sand's forge (below) at Birdsboro. (Photographs courtesy of J. D. Knox.)



In contrast to production rates of old furnaces, modern blast furnaces such as the Bethlehem unit shown above produce 1000 tons or more per day.

Valley Creek was in operation in 1751, using pig iron supplied by Warwick furnace.

History further mentions the Vincent steel works erected on French Creek in 1750, the Windsor forges built on Conestoga Creek in 1742, Hopewell furnace on French Creek, Union and Pottsgrove forges in the Schuylkill valley, Sarum iron works in Delaware county, Charming and Moselen forges in Berks county, a forge on Crum Creek near Chester, and a rolling and slitting mill and nail factory at Birdsboro. Cornwall furnace at Lebanon, Pennsylvania, was one of the prominent pioneers of the district and was still producing charcoal iron in 1892.

In 1750 two furnaces in Philadelphia were in operation producing blister steel, a process wherein wrought iron or puddled iron was heated in stone boxes with charcoal for about two weeks, resulting in steel by cementation. The surface of these bars was blistered by the evolution of gas within the metal, giving rise to the product's name.

An early company of considerable historical interest is the Principio Company, owner of Accokeek furnace in Virginia, who built the Principio furnace in 1722 on Principio Creek, in Cecil county, Maryland. George Washington's father was one of the owners of this company, which subsequently expanded and, through two centuries of corporate evolution, became connected with the present day Wheeling Steel Corporation.

Although their total output was insignificant when judged by modern standards, the colonial iron works were of inestimable importance to the Continental army during the Revolutionary War. Also, the colonial ironmasters were pillars of strength in support of George Washington's army in the Revolutionary War, contrib-

Steel poured at the Midvale Company (below) goes principally into forgings and castings, many of which are machined and heat treated before shipment.

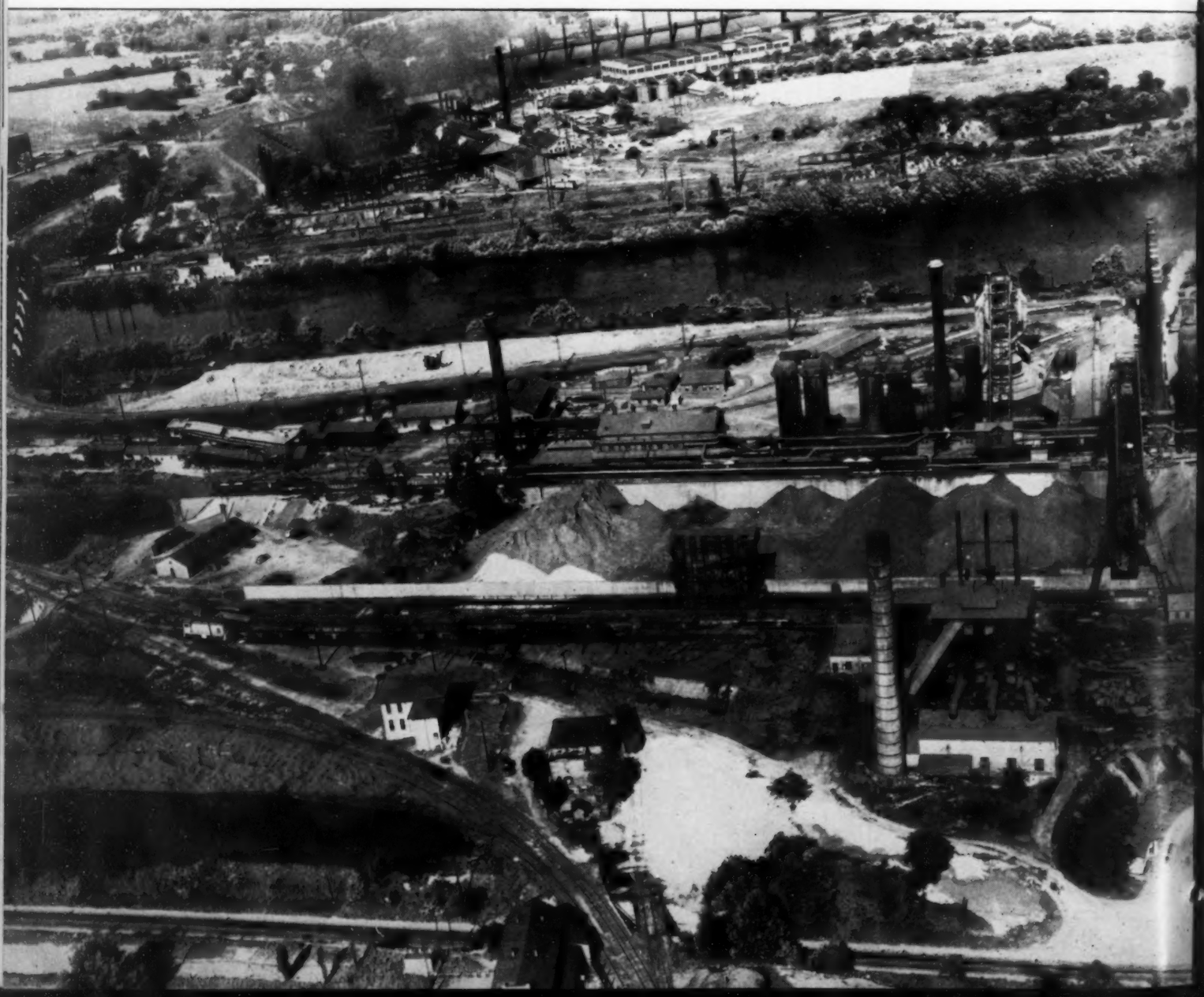
TABLE II

COKE CAPACITY

Philadelphia District

	By-product		Bee-hive		Total annual capacity, net tons
	Number	Net tons			
Alan Wood Steel Company, Swedeland, Pennsylvania	151	600,000	....	.....	600,000
Bethlehem Steel Company					
Bethlehem, Pennsylvania	416	1,680,000	....	.....	1,680,000
Steelton, Pennsylvania	130	648,000	....	.....	648,000
Sparrows Point, Maryland	422	2,124,000	....	.....	2,124,000
Total	1119	5,052,000	....	.....	5,052,000
Per cent of total United States					8.3

Alan Wood Steel Company is the descendent of a mill built at Conshohocken in 1832. The original mill produced sheets and was run by water power.



uting heavily of their own means to the support of troops in addition to providing iron for guns and other weapons. In fact, at least four signers of the Declaration of Independence were directly associated with the iron business: George Taylor of Durham furnace; James Smith, owner of Codorus forge in York County, Pennsylvania; Stephen Hopkins of the Hope furnace on the Pawtuxet River in Rhode Island, and George Ross, a lawyer of Lancaster, Pennsylvania, who was interested in Mary Ann furnace, the first furnace west of the Susquehanna River.

In 1800, Philadelphia was the largest iron producing center in the United States. As might be expected from a district which pioneered in the ferrous industry as well as in the formation of our country, the Philadelphia area can lay claim to many innovations in the industry of the United States. Among these are the following:

1816 — Wire fence made by White and Hazard, Schuylkill Falls, Pennsylvania.

1819 — First run of coke iron in America made at Bear furnace in Armstrong County, Pennsylvania.

1825 — First boiler plates rolled by Brandywine Rolling Mills at Coatesville, Pennsylvania.

1834 — Hot blast first used in the United States at Oxford furnace, New Jersey.

1835 — Coke first used in a blast furnace by Williams Firmstone at Mary Ann furnace, Huntingdon County, Pennsylvania.

1839 — Probably the first successful use of anthracite coal in a blast furnace by Benjamin Perry at Pioneer furnace, Pottsville, Pennsylvania.

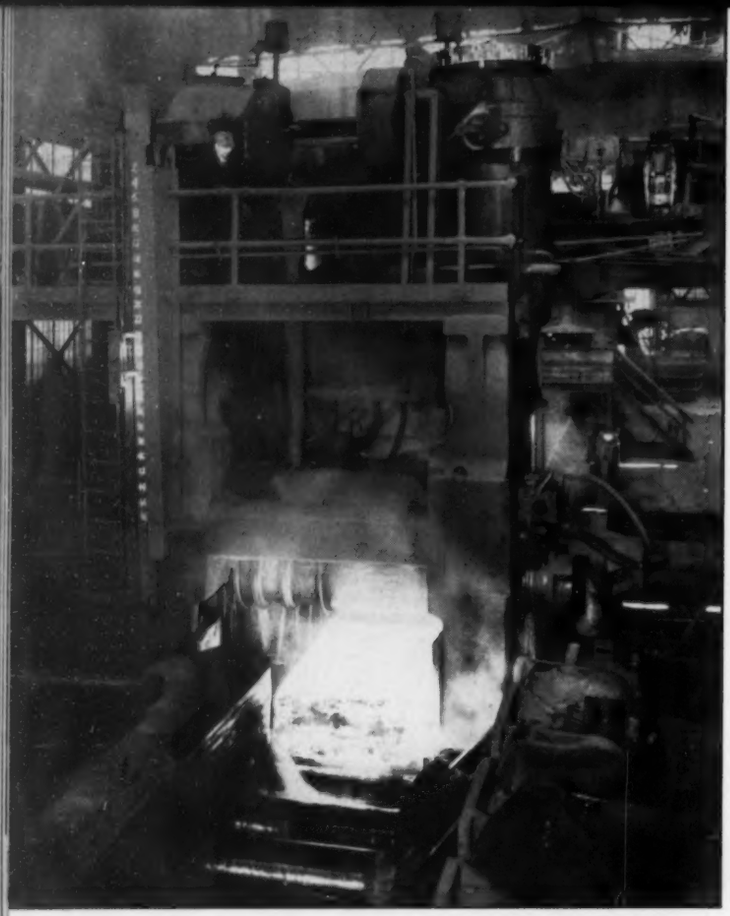
1844 — Heavy iron rails rolled at Mount Savage Rolling Mill, Allegany County, Maryland.

1852 — Wire nails first made in the United States by William Hassall, New York, New York.

1854 — Rolled wrought iron beams produced by Peter Cooper at Trenton, New Jersey.

1862 — Iron and steel columns as used in structural

The Bethlehem plant of Bethlehem Steel Company, where this 14,000 ton hydraulic forging press is located, has forging capacity of over 225,000 tons per year, in addition to extensive rolling facilities.



This 40 in. slabbing mill at the Sparrows Point plant of Bethlehem Steel Company has a rated annual capacity of 1,500,000 tons.

work invented by Samuel J. Reeves, of Phoenix Iron Company.

1868 — First open hearth furnace for steel manufacture built by Cooper, Hewitt and Company at New Jersey Steel and Iron Company, Trenton, New Jersey.

1884 — Basic steel made in a bessemer converter at Steelton, Pennsylvania, by Pennsylvania Steel Company.

1887 — Armor plates produced for the U. S. Navy Department by Bethlehem Iron Company.

Today the dominant producer in the Philadelphia district is the Bethlehem Steel Company, second largest in the country, with four major plants located in this area. Largest of these is the only tidewater plant on the Atlantic seaboard, located at Sparrows Point, Maryland. A far cry from the original blast furnace built on the bank of the Patapsco River about 60 years ago by the Pennsylvania Steel Company, this plant now includes 7 blast furnaces, 26 open hearth furnaces, 3 converters and 14 rolling mills, in addition to cold mills, sheet mills, finishing facilities and auxiliary equipment. At present a major expansion is under way at Sparrows Point which will greatly increase this plant's capacity for flat rolled products.

Second largest plant in the district is at Bethlehem, Pennsylvania. Here are 7 blast furnaces, 32 open hearth furnaces, 8 electric furnaces, and 16 rolling mills. This plant also supplies steel to the Lebanon plant, where 4 bar mills are installed.

At the Steelton plant, near Harrisburg, Pennsylvania, are 3 blast furnaces, 11 open hearth furnaces and 3 rolling mills.

These Bethlehem plants thus comprise about 67 per cent of the district's ingot capacity. Their operations are well integrated, with well diversified finishing capacity. Products from these plants cover practically the entire range of finished products turned out by the industry. Export sales of the company normally run well ahead of the industry's average.

Among the larger producers of this area is the Lukens Steel Company at Coatesville, Pennsylvania, one of the oldest American steel companies. Established in 1810 on Brandywine Creek by Isaac Pennock, this plant first produced charcoal iron and plates for slitting into rods. Between 1825 and 1854 this company was managed by Rebecca Pennock Lukens, probably the only woman to actively run a steel producing plant. The company has had a continuous line of family ownership and management. Acid open hearth steel was made at this plant in 1892, and basic open hearth steel four years later.

At present the Lukens plant contains 13 open hearth furnaces, two large two-stand plate mills (including the 206 in. unit said to be the largest in the world), and a wide range of finishing and fabricating facilities. Rolled product is entirely plate. Two wholly owned subsidiaries, By-Products Steel Corporation and Lukenweld, Inc., produce plate shapes and welded assemblies, providing outlets for the products of the parent company.

Another pioneer producer in the Philadelphia district is the Alan Wood Steel Company at Conshohocken, Pennsylvania. In 1792 James Wood built a forge in Chester Valley, where he made hammers. Later, in 1818, he operated a forge at Valley Forge, producing agricultural implements. Alan Wood, son of James, was first connected with the Delaware Iron Works, near Wilmington, Delaware, and in 1832 built the original Conshohocken mill which produced sheets, using water power. In 1857, with Lewis A. Lukens a partner in the firm, the division of the present company known as Schuylkill Iron Works was established. Open hearth furnaces and a blooming mill were built in 1903, and

Threading sucker rods at Bethlehem's Lebanon plant. In addition to hot rolled bars, this plant produces spikes, bolts, nuts, rivets, washers, pipe couplings and drop forgings.

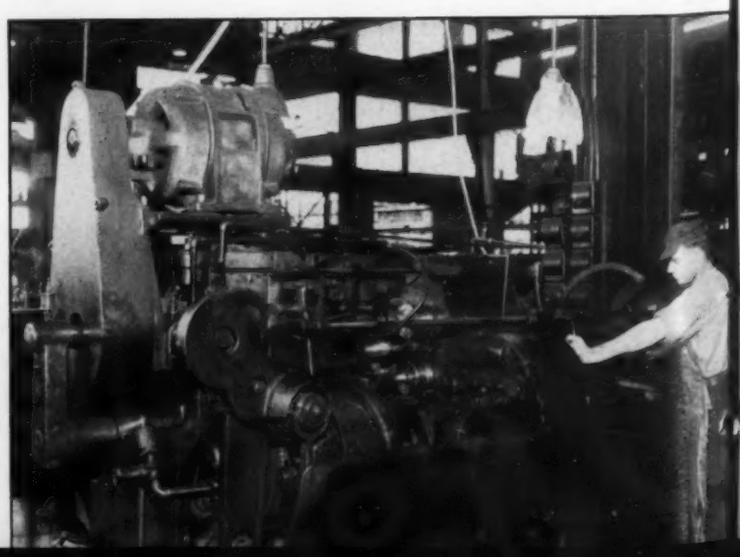


TABLE III

BLAST FURNACE CAPACITY

Philadelphia District

	Pig iron		Ferro-alloys		Total annual capacity, net tons
	Number	Annual capacity, net tons	Number	Annual capacity, net tons	
Alan Wood Steel Company, Swedeland, Pennsylvania	2	454,800	....	.....	454,800
Bethlehem Steel Company					
Bethlehem, Pennsylvania	7	1,920,000	....	.....	1,920,000
Steelton, Pennsylvania	3	792,000	....	.....	792,000
Sparrows Point, Maryland	7	2,712,000	....	.....	2,712,000
E. & G. Brook Iron Company, Birdsboro, Pennsylvania	1	137,890	.....	.....	137,890
E. J. Lavino and Company					
Sheridan, Pennsylvania	....	.....	1	36,000	36,000
Lynchburg, Virginia	....	.....	1	36,000	36,000
New Jersey Zinc Company, Palmerton, Pennsylvania	....	.....	2	134,400	134,400
Pittsburgh Ferromanganese Company, Chester, Pennsylvania	1	127,000	....	.....	127,000
Total	21	6,143,690	4	206,400	6,350,090
Per cent of total United States					9.4

TABLE IV

STEEL INGOT CAPACITY

Philadelphia District

	Open Hearth		Bessemer		Electric and Crucible		Total annual capacity, net tons
	Number	Annual capacity, net tons	Number	Annual capacity, net tons	Number	Annual capacity, net tons	
Alan Wood Steel Company, Ivy Rock, Pennsylvania	7	550,000	...	.....	...	.....	550,000
American Rolling Mill Company, Baltimore, Maryland	...	.....	...	.....	6	114,000	114,000
Baldwin Locomotive Works, Burnham, Pennsylvania	5	169,910	...	.....	1*	20	169,930
Bethlehem Steel Company							
Bethlehem, Pennsylvania	32	2,345,000	....	.....	8	158,000	2,503,000
Steelton, Pennsylvania	11	740,000	...	.....	1	.....	740,000
Sparrows Point, Maryland	26	3,835,000	3	240,000	...	.....	4,075,000
Carpenter Steel Company, Reading, Pennsylvania	...	.....	...	.....	6	74,880	74,880
Central Iron & Steel Company, Harrisburg, Pennsylvania	6	336,000	...	.....	...	.....	336,000
Crucible Steel Company of America, Harrison, New Jersey	1	30,000	...	.....	12	180,000	210,000
Henry Disston and Sons Company, Philadelphia, Pennsylvania	...	.....	...	.....	2	25,000	25,000
Harrisburg Steel Corporation, Harrisburg, Pennsylvania	3	100,750	...	.....	...	.....	100,750
Lukens Steel Company, Coatesville, Pennsylvania	13	624,000	...	.....	...	.....	624,000
Midvale Company, Philadelphia, Pennsylvania	8	430,830	...	.....	6	88,540	519,370
Phoenix Iron Company, Phoenixville, Pennsylvania	5	231,400	...	.....	...	.....	231,400
J. A. Roebling's Sons Company, Roebling, New Jersey	9	253,000	...	.....	...	.....	253,000
Worth Steel Company, Claymont, Delaware	7	460,000	...	.....	...	.....	460,000
Total	133	10,105,890	3	240,000	41†	640,440	10,986,330
Per cent of total United States							11.5

*Crucible. †Plus 1 crucible.

TABLE V

ROLLING MILLS

Philadelphia District

Company	Kind of mill	Size, inches	Number and type of stands	Annual rolling capacity, net tons
Alan Wood Steel Company				
Ivy Rock, Pennsylvania	Blooming	35	One, 2-high	330,000
	Sheared plate	84	Two, 3-high	145,600
Conshohocken, Pennsylvania	Jobbing	72	Two, 2- and 3-high	77,500
	Jobbing	56	Two, 2- and 3-high	
	Jobbing	48	One, 3-high	
	Sheet	48-72	Two, 2-high	
Alloy Metal Wire Company, Inc., Prospect Park, Pennsylvania	Strip cold finishing	3-10	Thirteen, 2-high	500
American Rolling Mill Company, Baltimore, Maryland	Blooming	28	One, 3-high	32,960
	Billet	20	Three, 3-high	
	Bar	12	Seven, 2- and 3-high	26,370
	Bar	9	Six, 2- and 3-high	
	Bar	12	Three, 2- and 3-high	16,480
	Bar	9	Seven, 2- and 3-high	
W. Ames and Company, Jersey City, New Jersey	Bar	10	Five, 3-high	35,000
Baldwin Locomotive Works, Burnham, Pennsylvania	Tire and ring	..	Four	44,000
	Wheel	..	Two	31,700
Bethlehem Steel Company				
Bethlehem, Pennsylvania	Blooming	40	One, 2-high	500,000
	Blooming	40	One, 2-high	500,000
	Blooming	46	One, 2-high	675,000
	Blooming	35	One, 2-high	450,000
	Billet	18	Six, 2-high	110,000
	Structural	48	Four, 2-high	525,000
	Structural	42	Four, 2-high	430,000
	Structural	28	Three, 3-high	275,000
	Structural	18	Three, 3-high	180,000
	Structural	12	Ten, 2-high	150,000
	Bar	22	Four, 2- and 3-high	225,000
	Bar	12	Seven, 2- and 3-high	130,000
	Bar	10	Six, 2- and 3-high	40,000
	Bar	8	Seven, 2- and 3-high	12,000
	Bar	12	Eight, 2- and 3-high	28,000
	Bar	9	Seven, 2- and 3-high	10,000
Steelton, Pennsylvania	Blooming	44	One, 2-high	675,000
	Rail	35-28	Four, 2-high	420,000
	Bar	20	Three, 3-high	160,000
Lebanon, Pennsylvania	Bar	10	Twelve, 2-high	150,000
	Bar	16	Four, 3-high	20,000
	Bar	12	Five, 3-high	20,000
	Bar	8	Six, 3-high	15,000
Sparrows Point, Maryland	Blooming	46	One, 2-high	900,000
	Blooming	40	One, 2-high	900,000
	Slabbing	40	One, 2-high	1,500,000
	Billet and Skelp	24	Four, 2-high	600,000
	Billet and Skelp	21	Seven, 2-high	
	Billet and sheet bar	24	Six, 2-high	600,000
	Billet and sheet bar	18	Six, 2-high	
	Skelp	12	Eight, 2-high	175,000
	Rod	10	Seventeen, 2-high	185,000
	Rod and bar	10	Twenty-one, 2-high	300,000
	Rail	26	Three, 3-high	120,000
	Sheared plate	114	One, 3-high	240,000
	Sheared plate	160	One, 3-high	275,000
	Universal plate	60	One, 2-high	320,000
	Jobbing	44-78	Two, 2-high	30,000
	Sheet, hot	34-62	Twenty-six, 2- and 3-high	200,000
	Sheet, cold	48-64	Six, 2-high	
	Hot strip	56	Ten, 2- and 4-high	1,200,000
	Strip, cold reduction	42	Five, 4-high	330,000
	Strip, cold reduction	42	Five, 4-high	330,000
	Strip, cold finishing	55-66	Three, 2-high	100,000
	Strip, cold finishing	42	Six, 4-high	660,000
Carpenter Steel Company, Reading, Pennsylvania	Breakdown and finishing	22	Three, 3-high	48,500
	Breakdown and finishing	16	Eight, 3-high	
	Bar	10	Thirteen, 3-high	
	Bar	12	Three, 3-high	
	Bar	10	Four, 3-high	
	Bar	10	Seven, 3-high	
	Bar	9	Six, 3-high	
	Cold strip	2½-12	Twenty-six, 2- and 4-high	6,500

TABLE V — Continued

ROLLING MILLS

Philadelphia District

Company	Kind of mill	Size, inches	Number and type of stands	Annual rolling capacity, net tons
Central Iron and Steel Company, Harrisburg, Pennsylvania	Sheared plate	126	One, 3-high	132,000
	Sheared plate	89	One, 3-high	50,400
	Universal plate	50	One, 2-high	105,600
Crucible Steel Company of America, Harrison, New Jersey	Billet	28	Two, 3-high	114,000
	Bar	16	Five, 3-high	21,000
	Bar	12	Five, 3-high	15,000
	Bar	10	Eight, 3-high	36,000
	Bar	9	Nine, 3-high	22,500
	Rod	9	Eleven, 2-high	20,000
Jersey City, New Jersey	Cold strip	5-16	One hundred, 2- and 4-high	9,600
Henry Disston and Sons, Inc., Philadelphia, Pennsylvania	Sheared plate	80	Three, 2-high	5,600
	Sheet, hot	28-34	Eight, 2-high	7,500
	Strip, cold	4½-22	Thirteen, 2-high	20,000
Wilbur B. Driver Company, Newark, New Jersey	Rod	9	Nine, 2-high	6,000
Eastern Stainless Steel Corporation, Colgate, Maryland	Sheet, roughing	84	Four, 2-high	15,000
	Sheet, finishing	84	Six, 2-high	
	Sheet, cold finishing	76-84	Eighteen, 2- and 4-high	8,000
Harrisburg Steel Corporation, Harrisburg, Pennsylvania	Blooming	32	One, 2-high	115,000
Heller Brothers Company, Newark, New Jersey	Bar	16	One, 3-high	16,800
	Bar	10	Seven, 3-high	
Hind Steel Company, Inc., Union, New Jersey	Strip, cold reduction	12	One, 4-high	3,000
	Strip, cold finishing	8	Eight, 2- and 3-high	
Janson Steel and Iron Company, Columbia, Pennsylvania	Billet	22	Two, 2-high	15,000
	Bar	12	Five, 3-high	
Jersey Shore Steel Company, South Avis, Pennsylvania	Bar	16	Two, 3-high	30,000
	Bar	12	Five, 3-high	
Logan Iron and Steel Company, Burnham, Pennsylvania	Bar	18	Four, 3-high	44,800
	Bar	12	Four, 3-high	
	Bar	10-8	Six, 3-high	
Lukens Steel Company, Coatesville, Pennsylvania	Sheared plate	206	One, 4-high	336,460
	Sheared plate	140	One, 3-high	
	Sheared plate	120	One, 4-high	300,000
	Sheared plate	112	One, 3-high	
Midvale Company, Philadelphia, Pennsylvania	Bar and billet	15	Two, 3-high	9,000
	Bar	12	Five, 3-high	6,000
	Bar	8	Five, 3-high	1,500
	Tire and ring	2	.....	.....
Milton Manufacturing Company, Milton, Pennsylvania	Bar	16	Two, 3-high	30,000
	Bar	10	Three, 3-high	
	Bar	10	Four, 2-high	
National-Standard Company, Clifton, New Jersey	Cold strip	4-9	Fifty-one	6,000
Phoenix Iron Company, Phoenixville, Pennsylvania	Blooming	36	One, 2-high	341,000
	Structural	24	Four, 3-high	169,000
	Structural	22	Four, 3-high	90,000
Pine Iron Works Company, Pine Forge, Pennsylvania	Sheared plate	84	One, 2-high	17,400
	Jobbing	84	One, 2-high	
Rockaway Rolling Mill, Rockaway, New Jersey	Bar	14	Two, 3-high	15,000
	Bar	10	Four, 3-high	
John A. Roebling Sons Company Roebling, New Jersey	Blooming	35	One, 3-high	168,000
	Billet	18	Four, 2-high	
	Rod	14-9	Twenty, 2-high	162,000
	Rod	18-10	Thirteen, 2- and 3-high	
Trenton, New Jersey	Cold strip	4-16	One hundred fifty-eight, 2-, 3-, and 4-high	24,000
Sweet's Steel Company, Williamsport, Pennsylvania	Rail	16	Two, 3-high	40,000
	Bar	14	Seven, 3-high	40,000
Ulster Iron Works, Dover, New Jersey	Muck	18	One, 3-high	17,000
	Bar	20	Two, 3-high	14,000
	Bar	16	Two, 3-high	7,000
	Bar	12	Three, 3-high	7,000
	Bar	10	Four, 3-high	10,000
Worth Steel Company, Claymont, Delaware	Sheared plate	160	One, 3-high	180,000
	Sheared plate	120	One, 3-high	120,000

TABLE VI

MISCELLANEOUS EQUIPMENT

Philadelphia District

	Soaking pit (holes)	Heating furnaces	Treating and annealing furnaces	Pickling units	Nail and staple machines	Wire drawing blocks	Galvanizing units	Tinning units	Forging hammers and presses	Cold draw benches	Tube mills
Alan Wood Steel Company											
Ivy Rock, Pennsylvania	18	6	....	....	....	....	....	....	....	....	....
Conshohocken, Pennsylvania	....	5	7	1	50	....	....	....	....	....	....
Alloy Metal Wire Company											
Prospect Park, Pennsylvania	....	....	....	....	....	165	....	....	....	....	....
American Rolling Mill Company											
Baltimore, Maryland	....	17	17	....	....	36	....	....	2	2	....
American Steel and Wire Company											
Trenton, New Jersey	....	....	....	....	....	400	3	....	....	....	....
W. Ames and Company											
Jersey City, New Jersey	....	2	....	....	....	....	....	....	....	....	....
Baldwin Locomotive Works											
Burnham, Pennsylvania	....	86	....	....	....	....	....	....	29	....	....
Bethlehem Steel Company											
Bethlehem, Pennsylvania	74	16	28	....	....	1	....	....	....	3	....
Steelton, Pennsylvania	26	6	....	....	....	....	....	....	6	....	....
Williamsport, Pennsylvania	....	....	4	....	....	466	....	....	....	....	....
Lebanon, Pennsylvania	....	7	....	....	....	....	2	....	7	....	....
Sparrows Point, Maryland	100	50	77	9	170	333	18	58	....	....	4
Bethlehem Lebanon Forge											
Lebanon, Pennsylvania	....	4	....	....	....	....	....	....	3	....	....
Carpenter Steel Company											
Reading, Pennsylvania	....	20	70	....	....	13	....	....	5	2	....
Central Iron and Steel Company											
Harrisburg, Pennsylvania	....	15	1	....	....	....	....	....	....	....	....
Crucible Steel Company of America											
Harrison, New Jersey	....	58	73	....	....	....	....	....	24	5	....
Jersey City, New Jersey	....	....	31	....	....	55	....	....	....	2	....
Henry Disston and Sons, Inc.											
Philadelphia, Pennsylvania	....	20	8	1	....	....	....	....	4	....	....
Wilbur B. Driver Company											
Newark, New Jersey	....	2	....	....	....	31	....	....	....	....	....
Eastern Stainless Steel Corporation											
Baltimore, Maryland	....	12	3	9	....	....	....	....	....	....	....
Harrisburg Steel Corporation											
Harrisburg, Pennsylvania	8	29	....	1	....	....	....	....	34	....	....
Heller Brothers Company											
Newark, New Jersey	....	17	....	....	....	....	....	....	10	....	....
Hind Steel Company											
Union, New Jersey	....	....	1	1	....	....	....	....	....	....	....
Igoe Brothers, Inc.											
Newark, New Jersey	....	....	....	....	....	47	....	....	....	....	....
Ivins Steel Tube Works, Inc.											
Philadelphia, Pennsylvania	....	....	....	....	....	....	....	....	....	....	....
Janson Steel and Iron Company											
Columbia, Pennsylvania	....	4	....	....	....	....	....	....	....	....	....
Jersey Shore Steel Company											
Jersey Shore, Pennsylvania	....	1	....	....	....	....	....	....	....	....	....
Keystone Drawn Steel Company											
Spring City, Pennsylvania	....	....	....	....	....	1	....	....	....	2	....
Logan Iron and Steel Company											
Burnham, Pennsylvania	....	17	....	....	....	....	....	....	....	....	....

TABLE VI — Concluded

MISCELLANEOUS EQUIPMENT

Philadelphia District

	Soaking pit (holes)	Heating furnaces	Treating and annealing furnaces	Pickling units	Nail and staple machines	Wire drawing blocks	Galvanizing units	Tinning units	Forging hammers and presses	Cold draw benches	Tube mills
Lukens Steel Company Coatesville, Pennsylvania	70	13	1	....	....	....	....	....	....	....	....
Midvale Company Philadelphia, Pennsylvania	....	207	5	....	....	....	....	....	25	....	....
Milton Manufacturing Company Milton, Pennsylvania	....	3	....	....	....	....	....	....	2	....	....
National-Standard Company Clifton, New Jersey	....	5	....	1	....	....	....	....	....	....	....
Phoenix Iron Company Phoenixville, Pennsylvania	22	2	....	....	....	....	....	....	....	....	....
Pine Iron Works Company Pine Forge, Pennsylvania	....	2	....	....	....	....	....	....	....	....	....
Pipe and Tube Products, Inc. Jersey City, New Jersey	....	....	....	....	....	....	....	....	....	....	....
Rockaway Rolling Mill Rockaway, New Jersey	....	3	....	....	....	....	....	....	....	....	....
John A. Roebling's Sons Company Roebling, New Jersey	8	6	....	....	....	2074	....	....	....	....	....
Trenton, New Jersey	....	....	8	3	....	168	3	....	5	....	....
South Chester Tube Company Chester, Pennsylvania	....	1	....	....	....	....	....	....	....	....	1
Summerill Tubing Company Bridgeport, Pennsylvania	....	....	....	....	....	....	....	....	....	1	....
Sweet's Steel Company Williamsport, Pennsylvania	....	2	....	....	....	....	....	....	....	....	....
Tube Reducing Corporation Wallington, New Jersey	....	....	....	....	....	....	....	....	....	22	....
Ulster Iron Works Dover, New Jersey	....	22	....	....	....	....	....	....	....	....	....
Webb Wire Works New Brunswick, New Jersey	....	....	....	....	....	165	....	....	....	....	....
Worth Steel Company Claymont, Delaware	....	5	....	....	....	....	....	....	4	....	....

two blast furnaces and a coke plant were subsequently acquired.

At present, Alan Wood consists of two blast furnaces, 7 open hearth furnaces, and blooming, plate, jobbing and sheet mills. Products consist of basic, bessemer, malleable and foundry pig iron, steel ingots, blooms, billets, slabs, plates, sheets and nails.

The Midvale Company, in Philadelphia, although possessing a considerable capacity for steel production by open hearth (basic and acid) and electric furnace processes, has little rolling capacity. Products consist principally of forgings and castings, with some bars and forging ingots of special analyses. A good portion of the forged and cast product is machined and heat treated. Included in the range of products are heavy shafting, hydraulic parts, steel rolls, crank shafts, turbine wheel buckets, guns and gun forgings, armor plate, projectiles, railway tires, weldless rings and high pressure vessels and containers. The plant contains eight open hearth furnaces (four basic and four acid), six electric furnaces, three rolling mills, two tire mills, eleven forging hammers, and fourteen forging presses.

Carpenter Steel Company, at Reading, Pennsylvania, although relatively small, is well established in its business. Incorporated in 1904, it is the successor to a business started in 1889. The Reading plant now consists of six electric furnaces, breakdown and bar mills, and finishing equipment. It produces steel of the "stainless" and high alloy types, selling it as ingots, billets, slabs and cold-rolled strip.

Two more steel producers are located at Harrisburg. They are the Central Iron and Steel Company and the

Harrisburg Steel Corporation. The former, which is this year celebrating the 50th anniversary of its incorporation, consists of six open hearth furnaces and three plate mills, and produces sheared and universal plates, checkered floor plates, flanged and dished heads, and steel stampings. The latter company, incorporated in 1899, contains three open hearth furnaces, a blooming mill, six forging hammers and 28 forging presses. Products include blooms, billets, slabs, seamless steel cylinders, forgings, pipe flanges and coils.

Other steel producers in the Philadelphia territory include the following:

Henry Disston and Sons Company in Philadelphia, with two electric furnaces, bar, plate and sheet mills, and forging hammers; producing electric steel ingots, billets and bars, tool steel bars, cutlery, file and saw steels, armor plate, cold rolled strip and forged products.

Worth Steel Company, in Claymont, Delaware, with seven open hearth furnaces, plate mills, forging presses and spinning machines; producing sheared steel plates in a wide variety of analyses, flanged and dished heads, and miscellaneous fittings.

Phoenix Iron Company in Phoenixville, Pennsylvania, with five open hearth furnaces, and blooming and structural mills; producing heavy and light structural shapes and merchant bars.

Baldwin Locomotive Works, in Burnham, Pennsylvania, with five acid open hearth furnaces, tire and wheel mills, forging hammers and presses; producing tires, wheels, rings, flanges, springs, forgings and castings.

John A. Roebling's Sons Company, at Trenton and Roebling, New Jersey, with nine open hearth furnaces (acid and basic), blooming, billet, rod and strip mills, forging hammers, and wire drawing facilities; producing cold rolled strip, wire rope, cables, round and shaped wire, wire cloth and netting, and cable fittings. The founder of this company engineered the construction of the Brooklyn suspension bridge, built 1869-1883 of American made steel wire cable.

Crucible Steel Company of America, at Harrison and Jersey City, New Jersey, with one acid open hearth and 12 electric furnaces, billet, bar, rod and cold strip mills, forging hammers and presses; producing high grade ingots, billets, bars, rods, wire, cold rolled strip, and forgings, principally for specialized applications.

American Rolling Mill Company (Rustless Division) at Baltimore, Maryland, with six electric furnaces, blooming, billet, bar and rod mills, and forging presses; producing chrome iron and chrome-nickel-iron alloys in ingots, billets, bars, sheet bars, rods and wire. This plant employs a patented process for the direct reduction of chrome ore.

Rails, which form a major portion of the production at Steelton plant of Bethlehem Steel Company, are given a final inspection before shipment.

In addition to the steel producers listed in the foregoing, there are approximately 25 additional companies operating only rolling mills, cold drawing equipment, forging equipment, etc., and four companies operating only blast furnaces, producing pig iron and ferro-alloys. Details of these plants are included in the accompanying tables.

Steel producers in the Philadelphia district now receive coal by rail, principally from West Virginia. Fuel oil is brought in chiefly by ocean-going tankers from Texas, Mexico, etc. Approximately 70 per cent of the iron ore requirements come from the lake ranges, with some coming from eastern magnetite fields and a goodly portion coming from Cuba and Chile by ocean shipment. The long haul by rail for ore is considered something of a handicap to operating economy of the plants in this area. This is largely offset, however, by the availability of water transport for products. Sometime in the not-too-distant future, as the high grade ores of the Great Lakes region play out and benefication requirements increase the cost of the leaner ores, the availability of imported ore by water transportation may make the eastern coast definitely attractive to more steel producers. Philadelphia may return to its status of 1800, when it was the largest iron producing center in America.

Harrisburg Steel Corporation turns out many gas cylinders in addition to its regular production of blooms, billets, slabs and forgings.

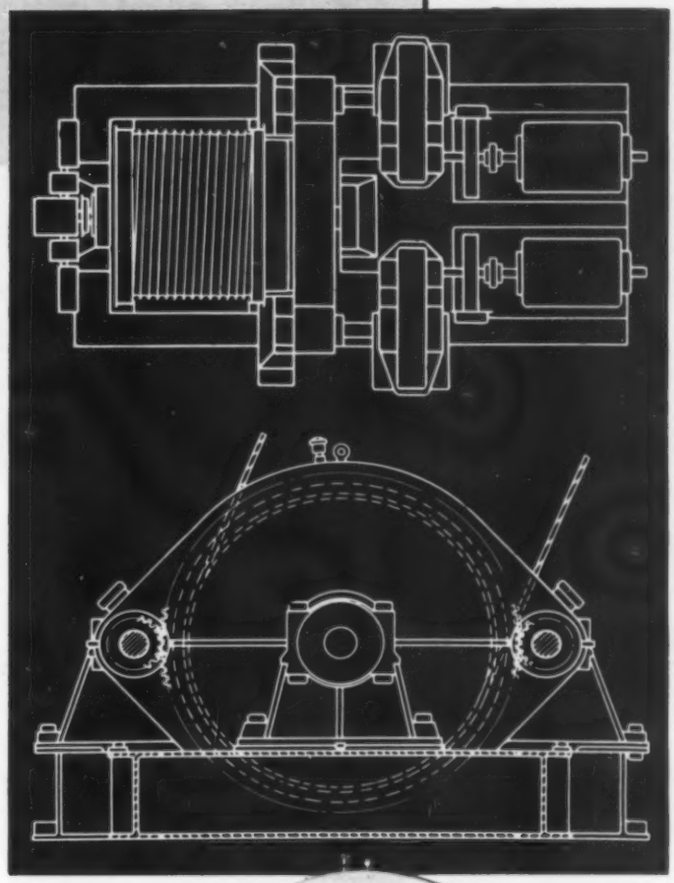
The FREYN-DESIGN BLAST FURNACE SKIP HOIST *with*

Symmetrically Arranged

Dual-Drive
(PATENTED)

is now the

RECOGNIZED STANDARD



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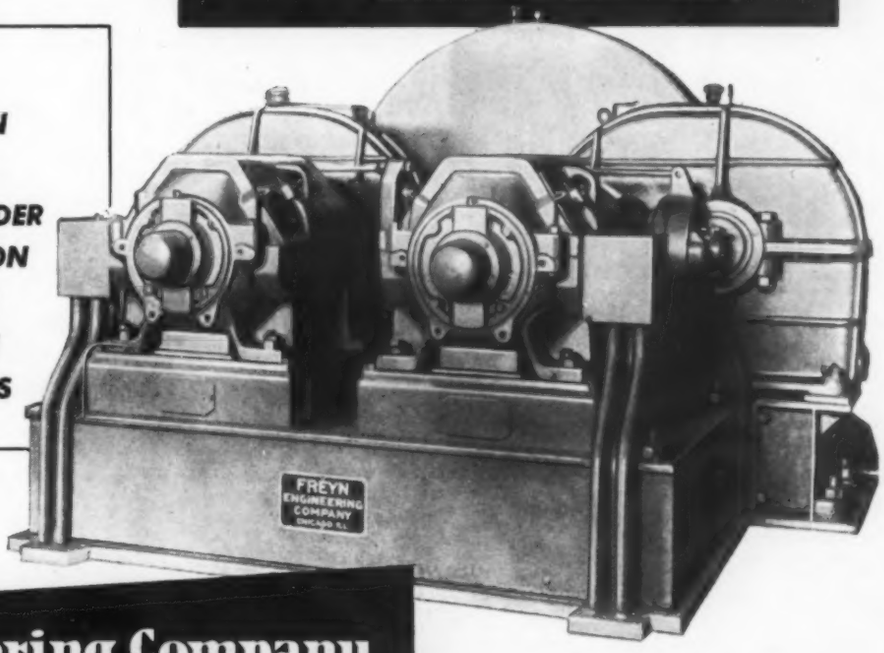
FREYN-DESIGN SKIP HOISTS ARE NOW ON ORDER FOR INSTALLATION AT AMERICA'S MOST MODERN BLAST FURNACES



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ASSOCIATED WITH
ASHMORE, BENSON, PEASE & CO. LTD., STOCKTON-ON-TEES, ENGLAND

•CRANE GEARS *Flame* HARDENED •••

Photo courtesy of Alliance Machine Company

THE strength and hardness of NELOY steel castings for crane gears result from a combination of alloying and special hardening. The desired hardness, together with increased strength for specified requirements, result from careful control by National-Erie metallurgists. NELOY castings meet with outstanding success because they are giving excellent service in many varied applications . . . on overhead traveling cranes, in rolling mills and steel works equipment, power shovels, drag lines, and other machinery.

HERE ARE THE QUALITIES OF NELOY FLAME HARDENING

1. No sharp line of demarcation between the case and the core nor quick change in chemical analysis as with case hardened material.

2. The surface material depends not on hardness alone, but combines high hardness and toughness to resist wear and impact.

3. A core value that is equal to that of alloy steel, offering fatigue or impact values much higher than the regular case hardened product.

4. Hardened depth for necessary wear resistance equal to case hardening treatment at about one-third the cost.

5. A surface that will not spall with vibration or impact.

Write for Your Copy of New Bulletin No. 7

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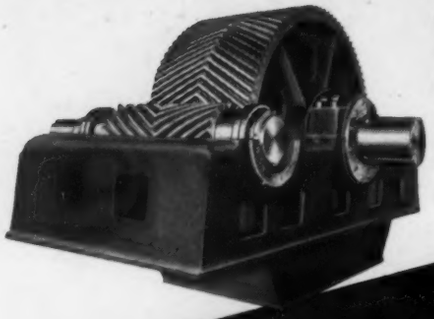
ERIE, PENNSYLVANIA • U. S. A.

the name to remember for big metal-cutting jobs

For fast, straight sawing of thick, tough plates, slabs and shapes, Lukens Steel Company uses Espen-Lucas Cold Sawing Machines. Hydraulic feeds, extra-rigid construction and speeds that can drive the largest saws through the heaviest cuts are Espen-Lucas qualities that are making it possible to speed up shipbuilding, gun, shell and other munitions jobs. Espen-Lucas Machine Works, Front Street and Girard Avenue, Philadelphia 23, Pa.

★ ★ ★ **ESPEN-LUCAS**

COLD SAWING MACHINES • ROTARY PLANERS
COLUMN FACERS • SPECIAL MACHINERY

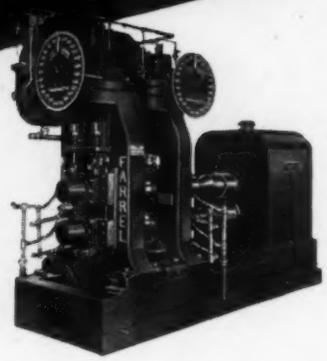


REDUCTION GEAR DRIVES—Designs include single, double and multiple reduction units, in a wide range of ratios and capacities. Continuous tooth herringbone gears — *The Gear with a Backbone* — precision generated by Farrel-Sykes process, provide extra load-carrying capacity and smooth, quiet operation.

FARREL MILL EQUIPMENT

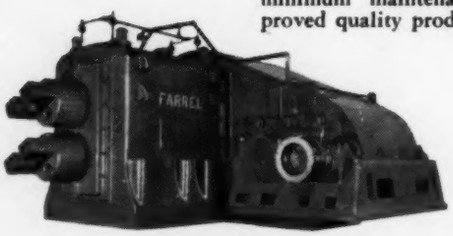
Engineered for Long Service

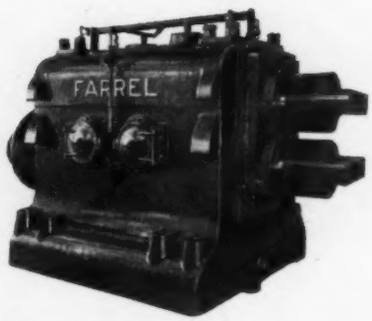
Farrel design gives you rolling mill equipment with operating stamina. At every vital point in each unit you find engineered protection which minimizes wear and preserves dependable performance. A few typical units are illustrated on this page. Information about them or similar units designed to fit your special requirements will be sent on request, without obligation.



ROLLING MILLS — Built in a wide range of sizes for non-ferrous rods, strips or sheets, metal foils and cold strip steel. Complete rod mills from furnace to coilers. Advanced design features contribute to efficient operation, high output, minimum maintenance and improved quality products.

COMBINATION DRIVE UNITS — Include reduction gear drive and pinion stand in compact, integral unit. Designed to withstand the shocks, stresses and wear encountered in continuous, heavy duty service.





PINION STANDS—Double or single helical pinions mounted in sleeve or roller bearings, carried in heavy cast cases, and provided with automatic lubrication. Designed for the job and built in any size and capacity.

ROLL GRINDERS—Built in two types—HD with traveling wheel, and TT with traveling work table—to take maximum diameters from 24″ to 60″, any length required between centers. Both types grind straight, concave and convex rolls, also shafts and other cylindrical work. Design features insure high quality work, precision and maximum output.

FARREL

FARREL ROLLING MACHINERY

- Rolls
- Rolling Mills
- Rod Mill Tables and Manipulating Equipment
- Universal Mill Spindles
- Rod Coilers
- Gears
- Mill Pinions
- Pinion Stands
- Gear Drives of any Capacity
- Flexible Couplings
- Roll Grinding Machines
- Roll Calipers
- Lead Presses for Pipe or Rod

FARREL-BIRMINGHAM COMPANY, INC., ANSONIA, CONN.

Plants: Ansonia, Derby and Stonington, Conn., Buffalo, N. Y.

Sales Offices: Ansonia, Buffalo, Stonington, New York, Boston, Pittsburgh, Akron, Chicago, Los Angeles, Tulsa, Houston, Charlotte

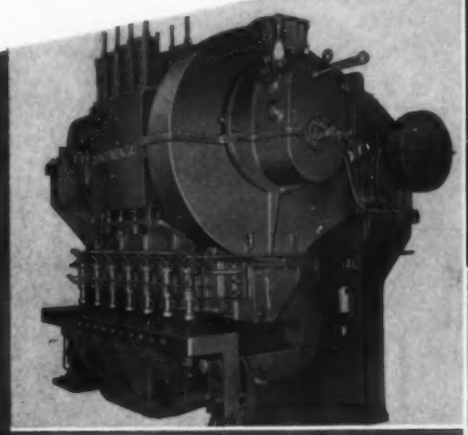
FB-396

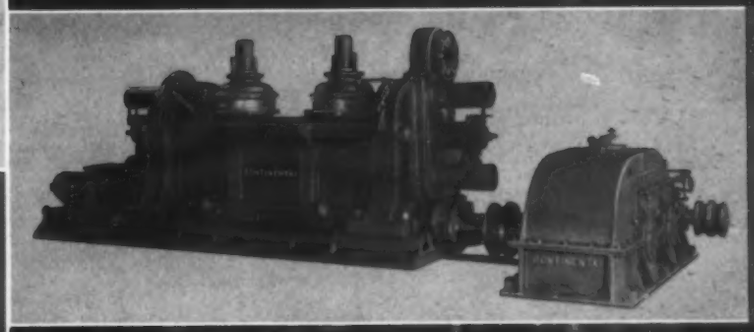
Farrel-Birmingham

a Specialty!

STEEL PLANT EQUIPMENT

Custom Engineered for Steel
Plant Expansion and Modernization





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FOUNDRY & MACHINE CO.

CHICAGO • PITTSBURGH

Plants at East Chicago, Ind. • Wheeling, W. Va. • Pittsburgh, Pa.

Industry's Headquarters for
Carbon and Alloy Steel Castings
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Iron and Steel Rolls

Never too big or too complex . . .

Continental

for dependable, uniform

CASTINGS

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Cutter Head for Hydraulic Dredge

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CONTINENTAL is headquarters for finest precision carbon and alloy steel castings of all types from 50 lb. production designs up to complex special castings weighing as much as 250,000 lbs. CONTINENTAL'S unexcelled facilities offer you the complete answer to all your casting requirements.

PROGRAM

Monday, May 26, 1947

9:00 a.m. — Registration — Mezzanine Floor

10:00 a.m. — Technical Meeting — Crystal Ball Room

Co-Chairmen:

Anders G. Ericson
Chief Engineer, Homestead Steel Works
Carnegie-Illinois Steel Corporation
Munhall, Pennsylvania

Louis Moses, Superintendent
Rail Mill and Roll Departments
Bethlehem Steel Company
Sparrows Point, Maryland

"DESIGN, CONSTRUCTION AND LUBRICATION OF MILL COUPLINGS AND SPINDLES," by William L. Stover, Mechanical Engineer, Mesta Machine Company, Pittsburgh, Pennsylvania.

"THE ART OF ROLLING HEXAGONS AND OCTAGONS," by Charles P. Hammond, Superintendent, Rolling Mills, Atlas Steels Limited, Welland, Canada

10:00 a.m. — Technical Meeting — Betsy Ross Room

Co-Chairmen:

C. R. Hand, Assistant Superintendent
Mechanical Department
Bethlehem Steel Company
Sparrows Point, Maryland

I. N. Tull, Electrical Superintendent
Republic Steel Corporation
Corrigan-McKinney Works
Cleveland, Ohio

"BEARING CONSTRUCTION AND PERFORMANCE CHARACTERISTICS," by E. Crankshaw, Assistant Chief Engineer, Cleveland Graphite Bronze Company, Cleveland, Ohio.

"WELDING OF STEEL STRIP FOR CONTINUOUS COLD ROLLING," by Henry Griffith, Welding Engineer, Federal Machine and Welder Company, Warren, Ohio.

2:00 p.m. — Technical Meeting — Crystal Ball Room

Co-Chairmen:

N. C. Bye, Director of Engineering
Henry Disston and Sons, Inc.
Philadelphia, Pennsylvania

S. C. Read, Superintendent, Rolling Mills
Jones and Laughlin Steel Corporation
S. S., Pittsburgh, Pennsylvania

"REMOTE CONTROL OF CONTINUOUS SLAB HEATING FURNACES," by C. E. Duffy, Assistant Fuel Engineer, Bethlehem Steel Company, Sparrows Point, Maryland.

"REPUBLIC'S CHICAGO 44, 36 AND 32 INCH MILLS — LAYOUT AND OPERATION," by R. F. Lavette, Superintendent 44, 36 and 32 Inch Mills, Republic Steel Corporation, Chicago, Illinois.

"THE MANUFACTURE OF WROUGHT STEEL WHEELS," By Robert Merk, Assistant to Chief Engineer, and William Ashton, Superintendent, Wheel and Axle Division, Carnegie-Illinois Steel Corporation, Munhall, Pennsylvania.

2:00 p.m. — Technical Meeting — Betsy Ross Room

Co-Chairmen:

M. B. Antrim, Technical Assistant to Electrical Superintendent
Lukens Steel Company
Coatesville, Pennsylvania

F. C. Schoen, Plant Engineer
The Midvale Company
Nicetown, Philadelphia, Pennsylvania

"PRODUCTION, POWER REQUIREMENTS AND DESIGN OF MODERN COLD DRAW EQUIPMENT," by Glenn W. Garwig, Sales Engineer, and A. L. Thurman, Assistant to the Vice President, Aetna-Standard Engineering Company, Youngstown, Ohio.

"PROBLEMS OF STRIP MILL SPEED-UPS," by F. Mohler, President, Patterson-Emerson-Comstock, Inc., Pittsburgh, Pennsylvania.

"MODERN METHODS OF FEEDWATER CONDITIONING FOR HIGH PRESSURE BOILER PLANTS," by S. D. Distelhorst, Cochrane Corporation, Philadelphia, Pennsylvania.

7:00 p.m. — DINNER — Crystal Ball Room
Speaker: Robert W. Wolcott, President,
Lukens Steel Company,
Coatesville, Pennsylvania.

Tuesday, May 27, 1947

INSPECTION TRIP

LUKENS STEEL COMPANY

COATESVILLE, PENNSYLVANIA

Buses will leave Benjamin Franklin Hotel, Philadelphia at 9:00 A. M., Tuesday, May 27, 1947. Evidence of United States or Canadian citizenship will be required of all participants. Only passengers on authorized buses will be permitted to enter the plant. Group luncheon will be served at noon.

Aerial view of the Lukens Steel Company, a pioneer steel producer of quality products.

M. B. ANTRIM

WILLIAM ASHTON

N. C. BYE

AUTHORS AND CHAIRMEN

E. CRANKSHAW

1947

C. E. DUFFY

ANNUAL SPRING CONFERENCE

ANDERS G. ERICSON

G. W. GARWIG

C. P. HAMMOND

C. R. HAND

R. F. LAVETTE

ROBERT MERK

F. MOHLER

AUTHORS AND CHAIRMEN
ANNUAL SPRING CONFERENCE

(Continued from preceding page)

LOUIS MOSES

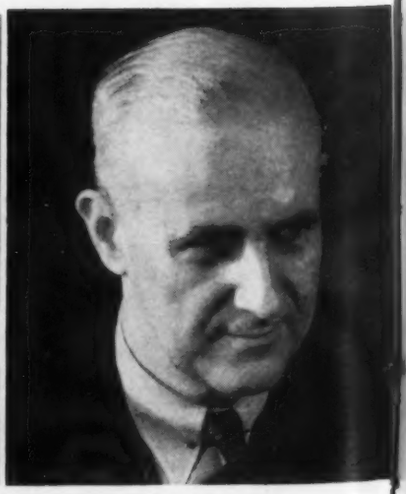
S. C. READ

F. C. SCHOEN

WILLIAM L. STOVER

A. L. THURMAN

I. N. TULL



A WELCOME to STEEL MILL OPERATORS and ENGINEERS

It is with the greatest of pleasure that I welcome the steel mill operators and engineers attending the Annual Spring Conference of the Association of Iron and Steel Engineers in Philadelphia. This Spring Conference is being held under the auspices of the AISE Rolling Mill Committee. However, this year an innovation is being made in that parallel technical sessions are scheduled, thus broadening the scope of the program including papers of general interest to all steel mill men, as well as to rolling mill operators.

A highlight of the 1947 Spring Conference is the inspection trip through Lukens Steel Company, a leader in the production of quality products and specialties.

We know that your participation in this program will give you new ideas which can be applied to your work, and which will result in greater economy of operations, thus enabling you to meet the demands of postwar production.

L. R. MILBURN

President, AISE

*'Surface' Continuous Annealing and Normalizing Furnace for treating a wide range of plate, varying from 3/16 inch to 1½ inches in thickness and up to 110 inches width. This furnace has a total inside length of 123 feet, of which 75 feet is devoted to the heating zone and 48 feet to the cooling zone.

It is equipped with 'Surface' High Pressure Velocity Burners for above and below hearth firing in the heating zone, and underfiring burners in the cooling zone to offset radiation losses when it is operated for blue annealing or slow cooling. In order to provide an extremely wide range of cooling, the cooling zone is equipped with a special flue gas cooler, dehydrator and recirculator.

'Surface'

SURFACE COMBUSTION CORPORATION

NACES *for* BIG MATERIALS

AT LUKENS PLANTS...

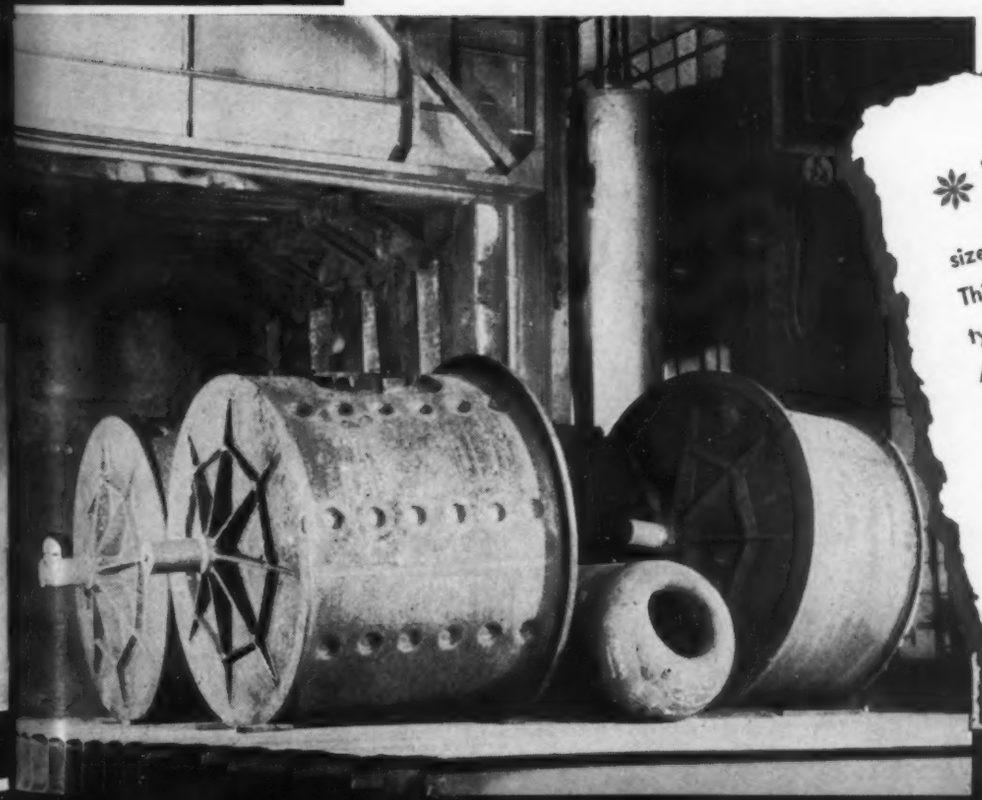
'Surface' PROVIDED FURNACES FOR SIZE, AND EXACTING CONTROL AND FLEXIBILITY OF USE, TOO!

FURNACE EQUIPMENT in steel producing and fabricating may necessarily be of special nature to meet the requirements of the materials to be processed. At Lukens Steel Company, and one of its subsidiaries, Lukenweld, Inc., this problem has been taken care of with the use of 'Surface' Industrial Furnace Equipment, especially engineered for the job.

Two of these units are herewith illustrated . . . a continuous annealer and normalizer—one of the largest of its type known for the processing of plate, and a giant size car-bottom type stress relieving furnace which utilizes convection heating in its operation.

These furnaces are representative of the almost unlimited kinds of furnaces and heating equipment 'Surface' offers to the steel mill. This equipment includes One-Way Fired Soaking Pits—Slab Heating Furnaces —Billet Reheating Furnaces—Continuous Heat Treating Furnaces for Plate —Pit Type Convection Furnaces for Annealing Rod, Wire, or Strip in coils— Continuous Strip Annealers and Normalizers—High Alloy Rod and Bar, Atmosphere Annealing Furnaces of Car-Bottom, Lift-Cover Type—Bright Annealing and Normalizing Furnaces for Tubing—Stress Relief Furnaces— Wire Patenting Furnaces—Annealing Covers, and the foremost equipment in Prepared Gas Atmosphere Generators for practically every heat treating operation.

It will pay you to submit your present heating and heat treating problems to 'Surface' for up-to-the-minute engineering advice and equipment.



✱ 'Surface' Car-Bottom Type Stress Relieving Furnace is used for various sized fabricated structural steel parts. This furnace is of a recirculating hot air type and is equipped with a 'Surface' Air Heater and a recirculating fan, mounted on the furnace top. It has a maximum load capacity of 80,000 pounds. Internal length from door to rear wall 21′-6″; Internal width from wall to wall 18′-6″; Width of car deck 16′-0″, and height from top of rails to underside of return air ducts is 11′-0″.

TOLEDO 1, OHIO

Abstracts of Technical Papers

ANNUAL SPRING CONFERENCE

MAY 26 - 27, 1947

PHILADELPHIA, PENNSYLVANIA

DESIGN, CONSTRUCTION AND LUBRICATION OF MILL COUPLINGS AND SPINDLES

By WILLIAM L. STOVER
Mechanical Engineer, Mesta Machine Company
Pittsburgh, Pennsylvania

The selection of the proper couplings and spindles is of prime importance in the design of any rolling mill. Excessive maintenance or breakdown of these parts seriously hampers the operation of the mill and cuts down its efficiency. In the design of the couplings and spindles there are limitations, imposed by roll size, on the outside dimensions of the couplings which govern the strength of these parts. This paper shows the relative sizes of each of the component parts of the standard universal couplings and spindles, and the old and still used muff coupling and spindle. Different designs of the universal coupling, as used by various mill manufacturers, are given with particular reference to the bearing segments, retaining pins, and the jaw half coupling. General methods of construction and materials used for the couplings are included, together with the various methods of assembling each particular type of finished product.

Some time is spent on the leading couplings, such as the Kennedy coupling, the commercial types and the universal coupling. The paper points out the advantages of each type of these couplings. Special leading couplings of the shear pin universal type are now in use with very marked success in protecting the mill against long breakdown periods. Methods of lubrication and dirt protection of these couplings are shown.

Each particular mill calls for special features in its couplings and spindles. The modern slabbing-blooming mill with its high lift is no exception. Spindles adaptable for shifting the jaw half coupling clear of the roll spade during roll changing are shown and discussed. The operations and design of the motor operated spindle shifters is included together with the balancing mechanisms for the top and bottom spindles.

The paper next shows a very interesting layout of a modern plate mill with a twin drive instead of the conventional motor and pinion drive as is commonly used. The arrangement of the motors, jack shaft, and the exceptionally long spindles is illustrated.

Layouts of typical hot and cold strip mills are shown with their particular type of couplings. Also shown are couplings and spindles for the mills such as the structural mills with two or more stands in line with their common pinion stand and drive. Special consideration of each spindle must be given.

THE ART OF ROLLING HEXAGONS AND OCTAGONS

By CHARLES P. HAMMOND
Superintendent, Rolling Mills
Atlas Steels, Ltd.
Welland, Ontario, Canada

This is the second paper presented by the author on the art of rolling, the first paper having been entitled "The Art of Rolling Rounds." In the preparation of these papers, the author has attempted to describe, first, the rolling procedure, and second, the different methods of rolling the section under discussion. The subject has been approached with the object in view of providing information for rolling mill personnel that will aid them to better understand the steps necessary to produce and maintain a section.

Producing a hexagon section is considered less difficult to roll than a round, since the flat surfaces and corners tend to assist in holding the bar as it passes through the rolls, and less guide assistance is required. However, the rolling procedure for a hexagon section still requires certain definite steps to be followed to produce sharp corners and uniform, flat surfaces.

The rolling procedure for an octagon is approximately the same as for a round since the bar must be held rigidly by the entering guides, particularly with the finishing pass. Considering that this section has corners and flat surfaces, it would seem a reasonable assumption that it would be less difficult to roll than the round section but this is not the case. The included angle between the flat surfaces is much greater than with the hexagon, and producing a symmetrical octagon section with eight sharp corners and uniform sides, does present more problems than the production of a symmetrical round.

It is important, in the efficient operation of any rolling mill, that the roll designer, his assistants and the roller have confidence in one another and work almost in perfect harmony. Take, for example, the careful technique and procedure that must be employed in the first application of a new section. The roll designer and his staff prepare the new rolls applying all the skills of their craft. The rolls are then properly assembled in the mill with the necessary guide assembly. It is at this stage that the resourcefulness of a good roller becomes evident. Each mill has its own peculiarities, and the roller must make adjustments and corrections with dispatch and good judgment as the first few bars are produced. He can, in many instances, through careful manipulation, produce the desired section. However, it is possible, after making all adjustments within the limits of the mill, that the proper section cannot be obtained and, at this point, the rolls may have to be taken

out of the mill, set up in the roll lathe and, perhaps, have the draught increased or decreased in one or more grooves. In making this decision regarding an alteration in the rolls, the understanding and co-operation between the roll designer and roller are manifest. These two men play a vital part in constantly improving upon the quality of the steel and the productive efficiency of the mill.

THE MANUFACTURE OF WROUGHT STEEL WHEELS

By ROBERT MERK, Assistant to Chief Engineer,
and
WILLIAM ASHTON, Superintendent,
Wheel and Axle Division
Carnegie-Illinois Steel Corporation
Munhall, Pennsylvania

This paper covers some of the manifold details involved in the manufacture of wrought steel wheels and related product, as made in plants of the Carnegie-Illinois Steel Corporation. Since practices at Gary steel works and Homestead district works are quite similar, except for minor modifications as a result of plant layout, Homestead practice is used as descriptive of steps involved.

A brief review is made covering the history of wheel making from early times, including background of manufacture at the present plant from time of founding by C. T. Schoen in 1903 up to present time.

Steps are covered in the manufacture of wheel blocks at Homestead, including practice at the open hearth, rolling at the blooming mills, followed by inspection and shipment to the Wheel and Axle plant at McKees Rocks, Pennsylvania. The important factors in the manufacture of rolled wheels are discussed, including heating, descaling, forging, wheel rolling, coning, stress relieving, slow cooling, heat treating, inspection, machining, and shipping of finished wheels. The manufacture of forged circular sections, axles and mounted wheel sets is treated briefly.

The paper emphasizes the extreme care required in inspection practices and in control over operating practices maintained at each step of manufacture in order to produce a product suitable for requirements of the industry, while continually looking forward to provide safer transportation for rail traffic at the high speeds of the future.

REMOTE CONTROL OF CONTINUOUS SLAB HEATING FURNACES

By C. E. DUFFY
Assistant Fuel Engineer, Bethlehem Steel Company
Sparrows Point, Maryland

When the hot strip mill was installed at Sparrows Point in 1937, three 18 ft × 80 ft triple zone recuperative furnaces were provided for heating slabs.

Manual fuel input control, automatic fuel-air ratio, and automatic furnace pressure control were provided. The controls and instruments were housed in individual control houses, each located between the furnaces. The operation of the controls and instruments was unsatisfactory, and their maintenance was very difficult because of the excessive heat in the area where the control houses were located.

(*Please turn to page 48-S*)

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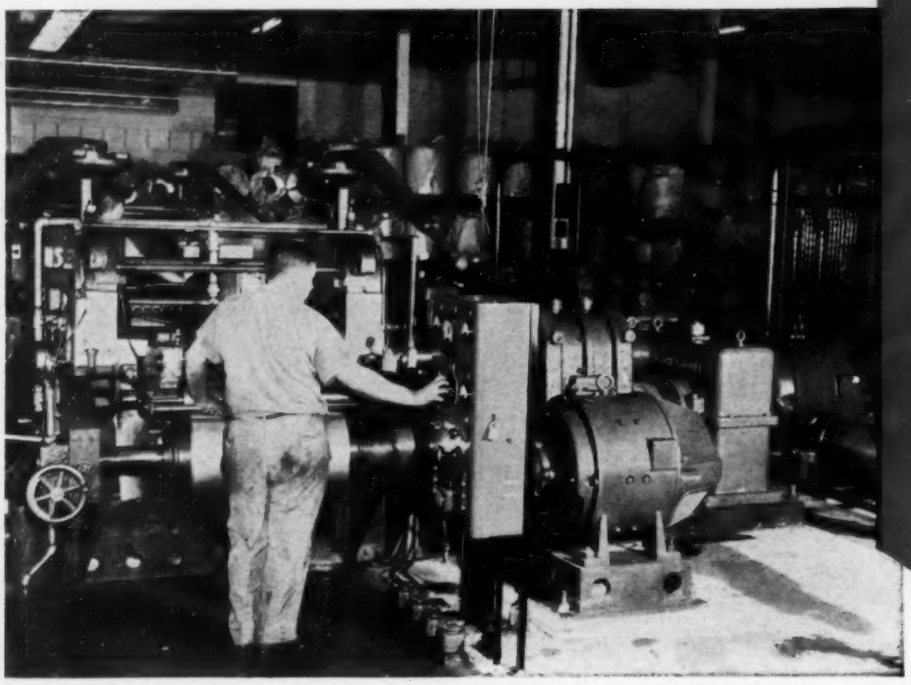

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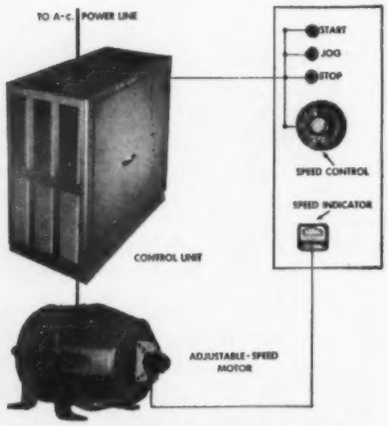

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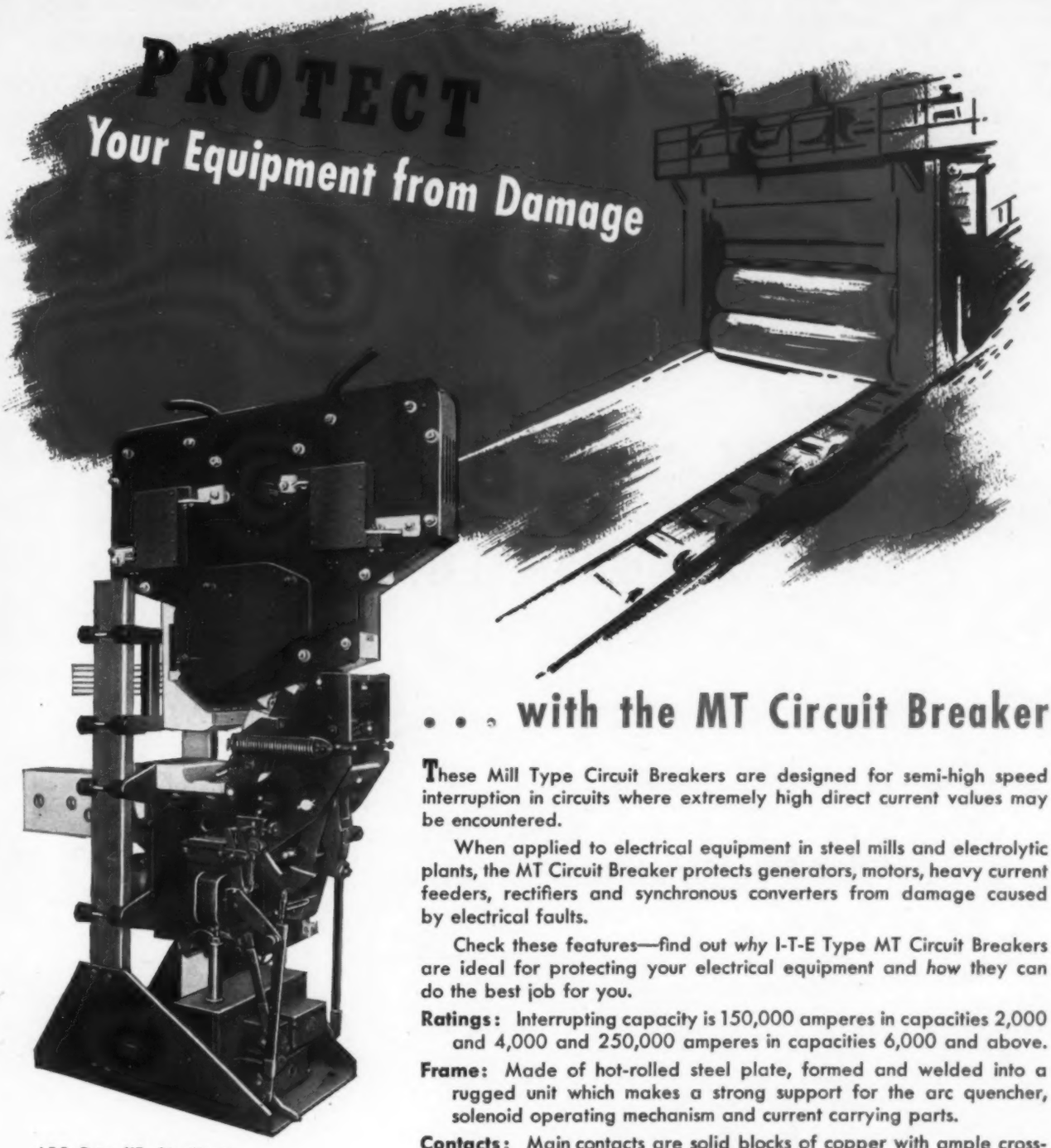

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Contacts: Main contacts are solid blocks of copper with ample cross-section to carry rated currents. Silver alloy inserts assure contact surfaces free from oxidation and overheating. Secondary contacts protect main contacts from arcing.

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(*Continued from page S-45*)

Therefore, when a fourth furnace was installed in 1945, it was decided to move all controls and instruments to a central control house located in a less overheated area. At the same time, furnace temperature control was installed on both the soaking and the heating zones, so that manual fuel input could be made automatic. All control regulators were air-loaded from the central control house.

The relocation of the instruments and controls from the overheated areas near the furnaces has had a marked effect on their operation both from an operating and a maintenance standpoint. The location of all instruments and controls at one central location has enabled the heater to check more easily on the conditions in the four furnaces.

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Bailey Pug Mills are designed and built to meet the most exacting demands of steel mill service, and are in use throughout the industry. The quality and dependability of these Mills are exemplified by one that operated for more than sixteen years continuously in one of the country's best-known sintering plants. Orders have recently been received from this company for two more Bailey Pug Mills.

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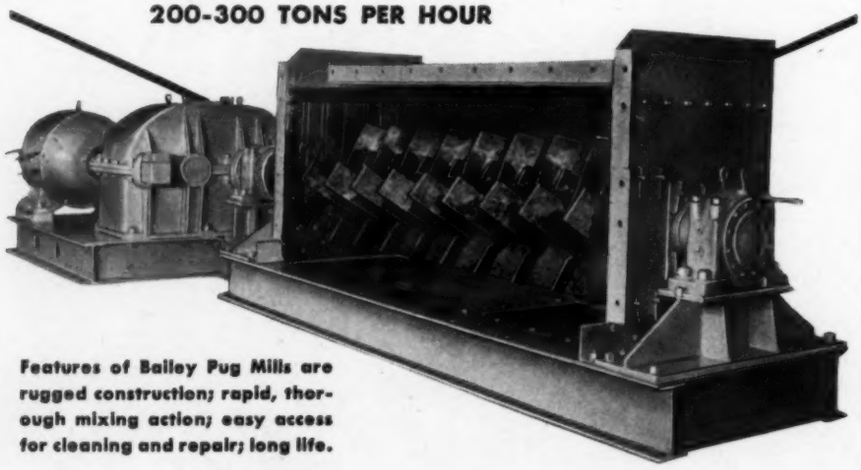

Features of Bailey Pug Mills are rugged construction; rapid, thorough mixing action; easy access for cleaning and repair; long life.

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BEARING CONSTRUCTION AND PERFORMANCE CHARACTERISTICS

By E. CRANKSHAW
Assistant Chief Engineer
Cleveland Graphite Bronze Company
Cleveland, Ohio

In making a bearing recommendation, there are many bearing performance characteristics to be considered. Among these are fatigue strength, surface action, corrosion resistance, and mechanical strength. The method of lubrication and the quantity of lubrication, as well as the quality of machining and assembly are also of prime importance.

A brief review is given of the development of various bearing constructions, showing the use of the white metals as a base for these changes because of their highly rated surface qualities. Here is told the evolution of the heavy babbitt which has been decreased in thickness in order to increase fatigue strength. With the reduction in thickness of this white metal surface layer has come the advisability of using an intermediate layer of copper-lead or silver in many applications. This development has been directed by the fact that tin-base babbitt, along with the lead-base white metals, is accepted quite generally as the preferred bearing material within its range of load carrying capacity.

In an effort to make it more clearly understood, a measuring stick is given on these various bearing constructions in respect to load carrying capacity and life. A chart is included showing the amount of load which can be carried successfully for a life of 100 hours, assuming satisfactory alignment and operating conditions.

Relative characteristics of the various bearing materials are tabulated in respect to fatigue resistance, surface behavior, and corrosion, as an aid to proper choice of material for a specific application. However, it should be borne in mind that the actual selection of material is dependent upon many additional factors including operating loads; installation factors such as alignment and distortion; operating conditions such as temperature, dust, and vapors; service factors; fuels and lubricants; and, as indicated, upon life expectancy.

In the last two decades there has

been a very definite trend to thinner wall bearings where the bearing housing masters the bearing rather than the reverse. This is a basic fundamental which is of primary importance if satisfactory operation and performance are to be expected.

Microphotographs are included showing variations in structure of the bearing materials which may result from proper control of quench as well as the factors which make it difficult to obtain the most advantageous structure.

An attempt has been made to correlate the above information so that it may be applied directly to the problems in bearing operation in such equipment as rolling mills. Indications are that much of the difficulty in rolling mill experience has been due to the fact that the bearing has not been properly seated in the bearing housing; consequently it is difficult to determine the conditions under which the bearing operates. The necessity for properly seating the bearing is stressed, and it is recommended that the physical dimensions of these assemblies be within reasonable limits to assist in diagnosing bearing failures.

ROLLING PRACTICE ON 44, 36 AND 32 IN. MILLS

By R. F. LAVETTE, Superintendent,
44, 36 and 32 in. Mills,
Republic Steel Corporation, Chicago, Illinois

The paper covers the 44-36-32 in. mills at the Chicago plant of the Republic Steel Corporation. These mills went into production in 1943 and 1944 and were part of a completely integrated steel plant, constructed during the recent war, for the production of electric furnace alloy steel for use in aircraft, guns, tanks, etc. The design of the mill was dictated by war product requirements. The whole mill except the soaking pit building is all under one roof.

The 44 in. mill was designed to handle 34×34×167 in. ingots weighing 34,000 lb. The mill is driven by a 7000 hp motor at 40 to 100 rpm.

Between the 44 in. mill and ahead of the bloom shear is a scarfing machine for hot scarfing blooms as they are delivered from the blooming mill to the shear. The machine scarfs all four sides simultaneously of blooms ranging in size from 6×6 in. to 14×16 in. at speeds up to 125 fpm.

The 44-36-32 in. mills are laid out all in line in one bay, which allows several methods of processing and makes it possible to operate each mill as a separate unit or in combination. Because of the weights involved in most of the sizes produced on the mills, it was necessary to provide mechanical manipulation at all stands.

In laying out and designing these mills, every effort was made to make use of mechanical and other equipment to take care of handling problems. For example, coke breeze for soaking pit bottoms is dumped into a track hopper from hopper bottom cars, elevated to overhead bins by conveyor, and feeds by gravity to boxes for distribution to the pits by soaking pit cranes. Soaking pit covers have dual controls and can be used by either the craneman or heater. Mill scale in the 44 in. mill is handled by a combination of mechanical conveyor and flushing system to sump pits, and scale from the 36 and 32 in. mills is flushed to the pits by water.

PRODUCTION, POWER REQUIREMENTS AND DESIGN OF MODERN COLD DRAW EQUIPMENT

By GLENN W. GARWIG and A. L. THURMAN
Aetna-Standard Engineering Company
Youngstown, Ohio

This paper describes recent developments in cold draw equipment including drawbenches for tubes and bars, and different types of tube and bar pointers. The paper explains the operation of drawbenches, gives detailed description of the various components of tube and bar benches, and furnishes data on the production capabilities of both types of benches.

Information on power requirements including test data for both tube and bar benches is furnished. Description of the new triple draw tube benches is given, including rack type, reversing dual chain, and non-reversing single chain type.

Push pointing of tubes and bars is discussed, including recent improvements to this type of pointing. The practice of push pointing of tubes in England is also described. Developments in electric equipment for drawbenches are presented.

Slides showing charts and photographs as well as motion pictures are used to illustrate the paper.

PROBLEMS OF MILL SPEED-UPS

By F. MOHLER, President
Patterson-Emerson-Comstock, Inc., Pittsburgh, Pa.

▲ To many who have not delved into the detail problems of speeding up strip mills, it is only a question of increasing motor speeds and horsepowers. This is far from true, however, if a reasonable return on a given investment is to be obtained in the way of production of the proper quality strip.

There are good and sufficient reasons for speeding up the rates of acceleration and deceleration as the delivery speeds of mills increase. The proper rates depend upon the maximum speed of the mill, the size of coils, the width and gauge of coils, the range of products to be rolled, and economic considerations. An approach to the evaluation of the factors will be discussed.

Once the desired rates of acceleration and deceleration are determined, the real problems involved present themselves. If you endeavored to express all of these problems in one word, that word would be inertia. Inertia in general falls into two classes — mechanical and electrical. By and large, designing for the lowest mechanical inertia is diametrically opposite to the best electrical performance. Thus it becomes a matter of judgment as to where to compromise. This logical procedure might take us through mechanical and electrical designs, such as a single armature with step-down gear or direct drive, a double armature direct drive, a triple armature direct drive, a twin drive, or even a step-up gear drive.

Where should we stop putting money into fundamental machine design and rely on the control to take care of the problems? Where does the individual generator for each system versus the common bus system fit into the picture? What are the various control problems involved? These are some of the questions which will be answered in this paper.

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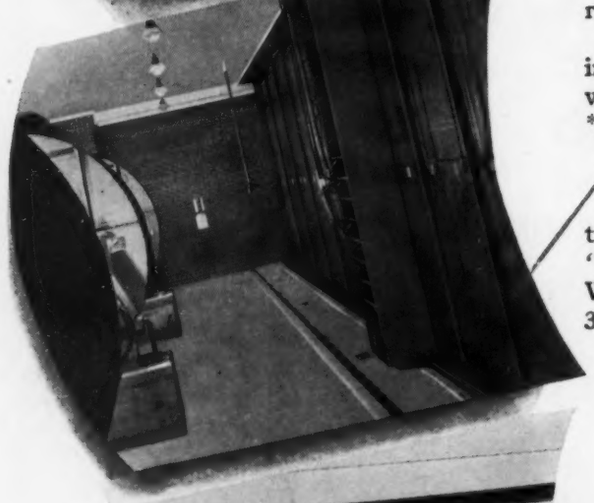

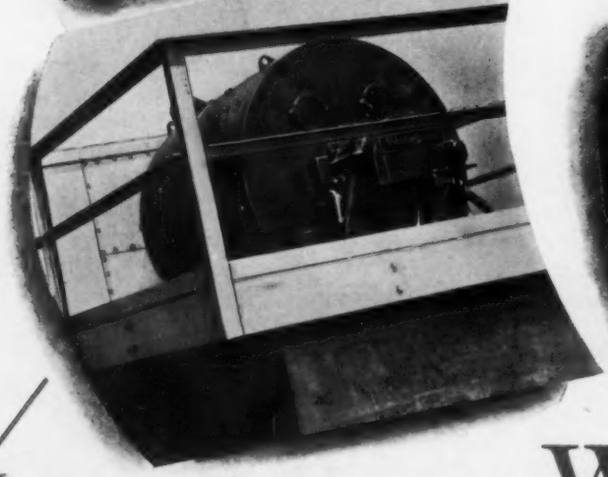

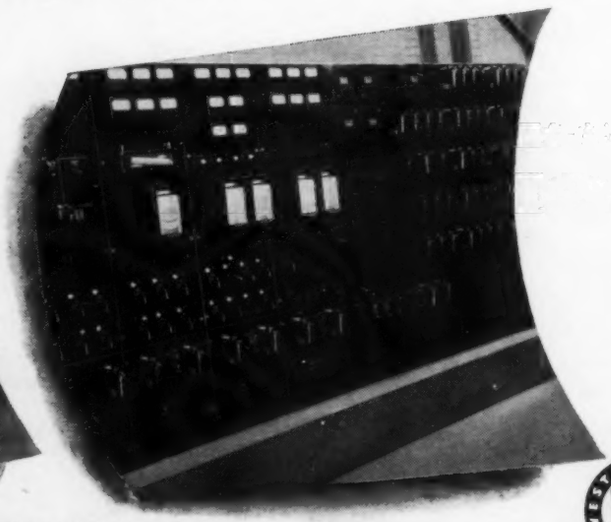

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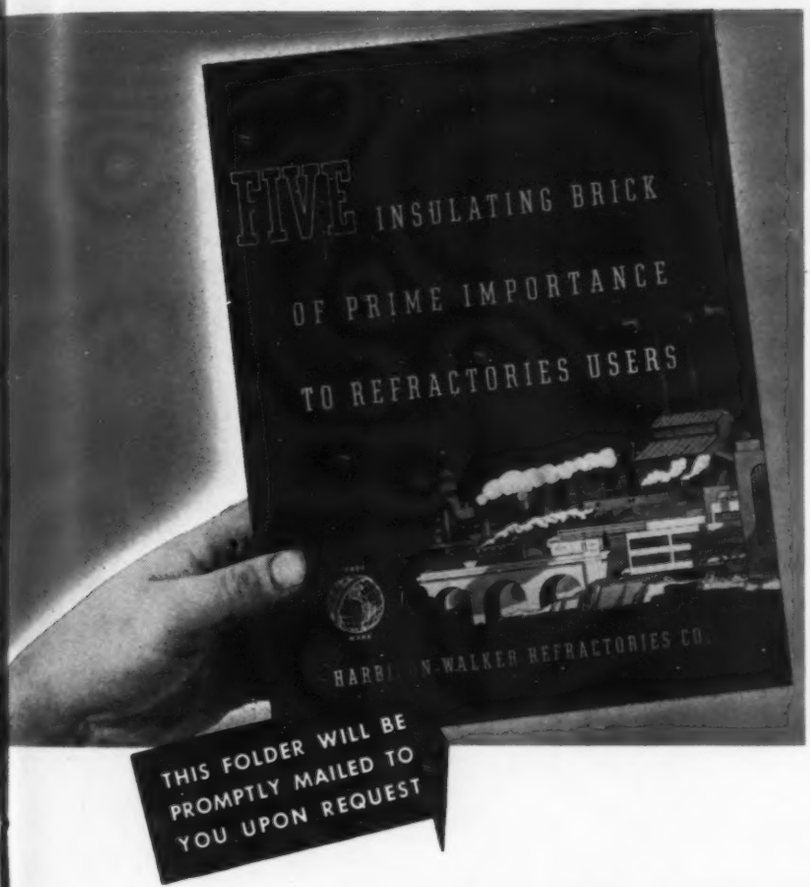

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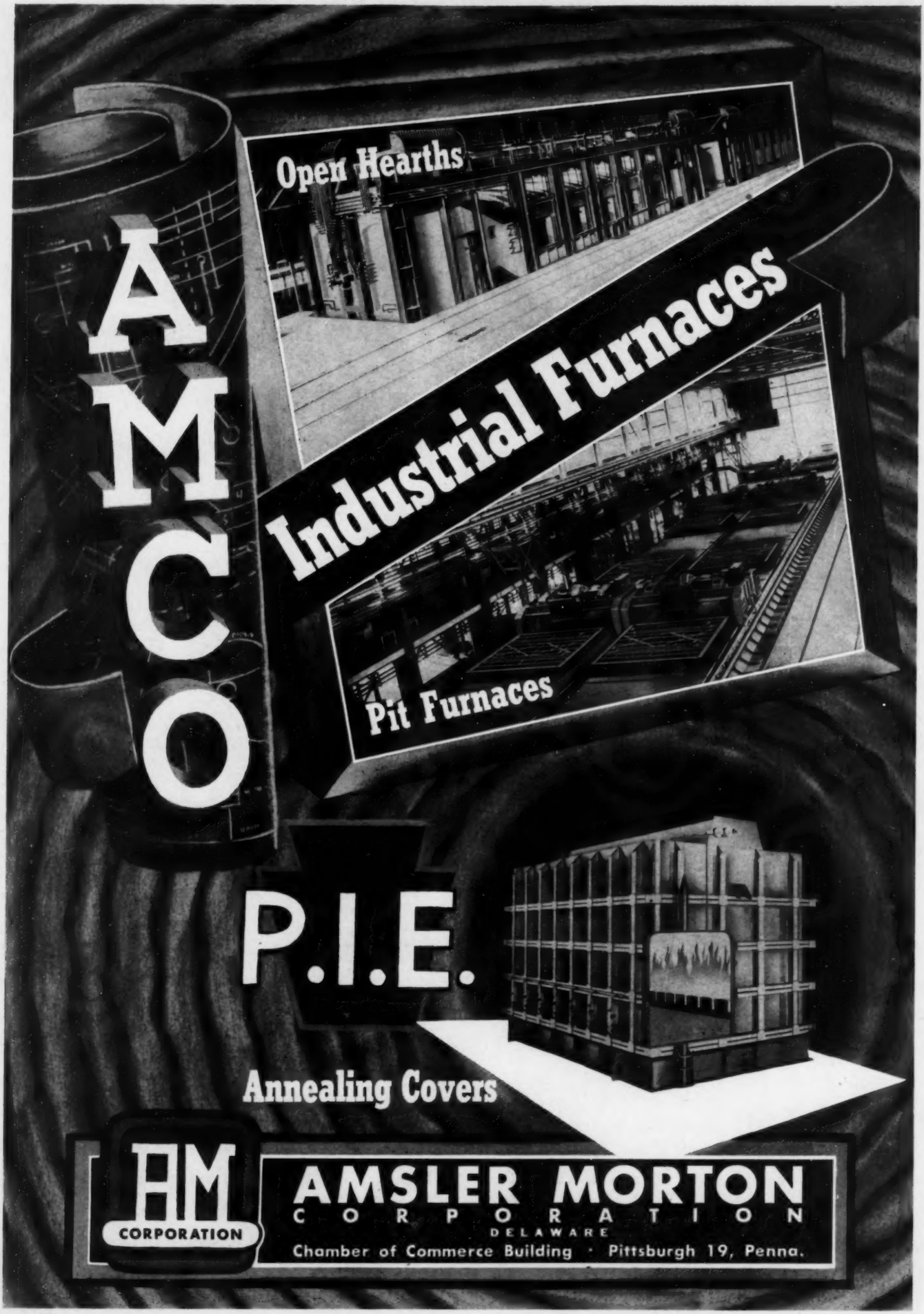
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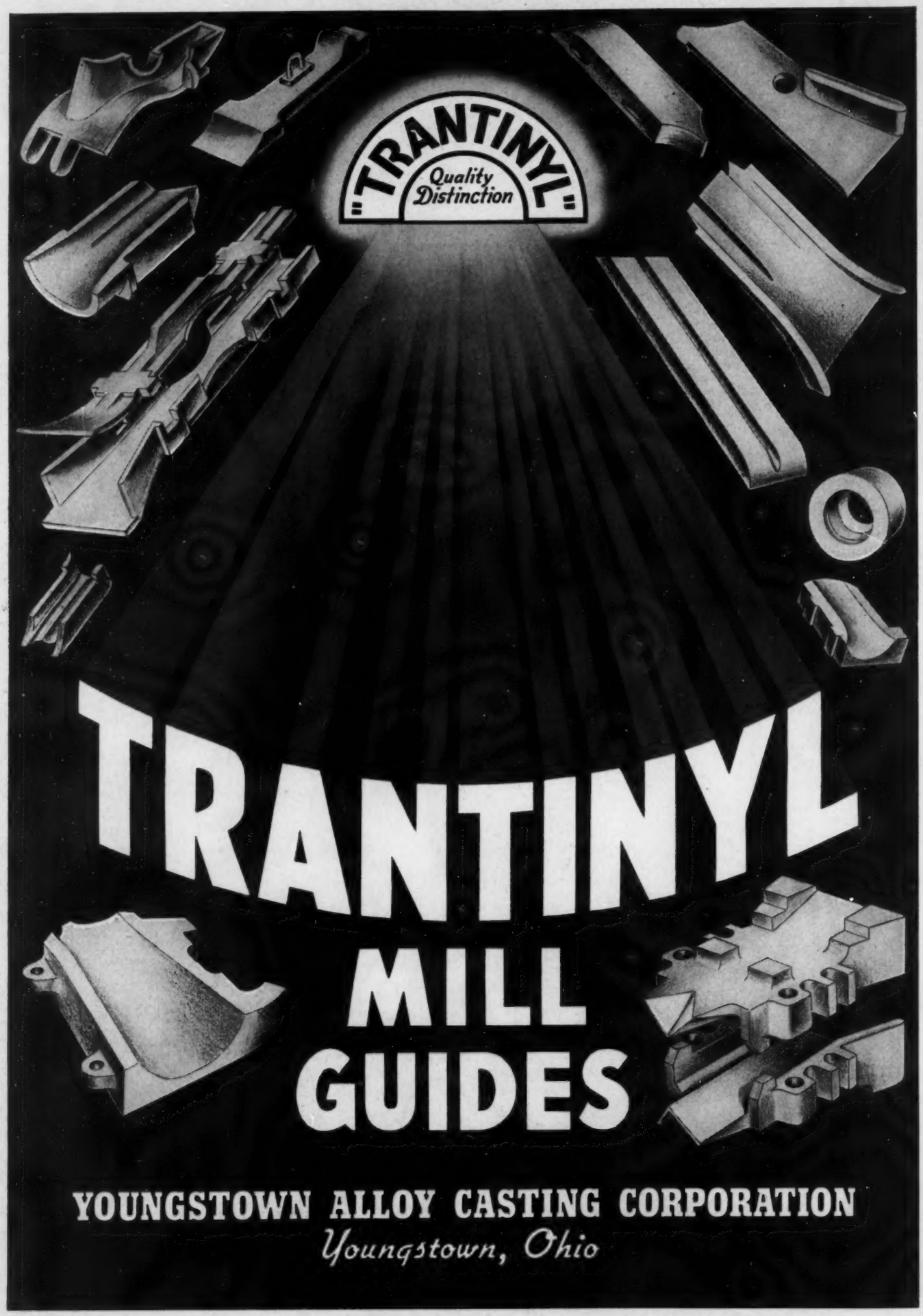
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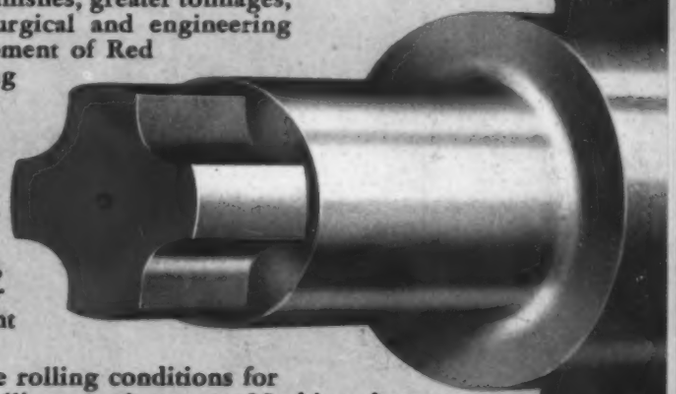

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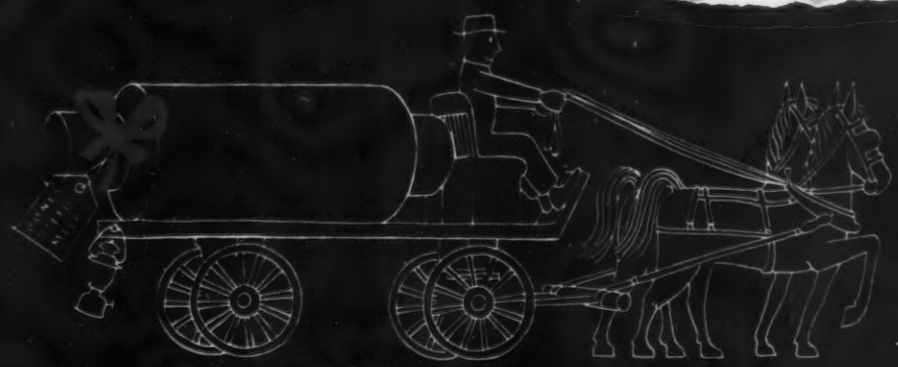

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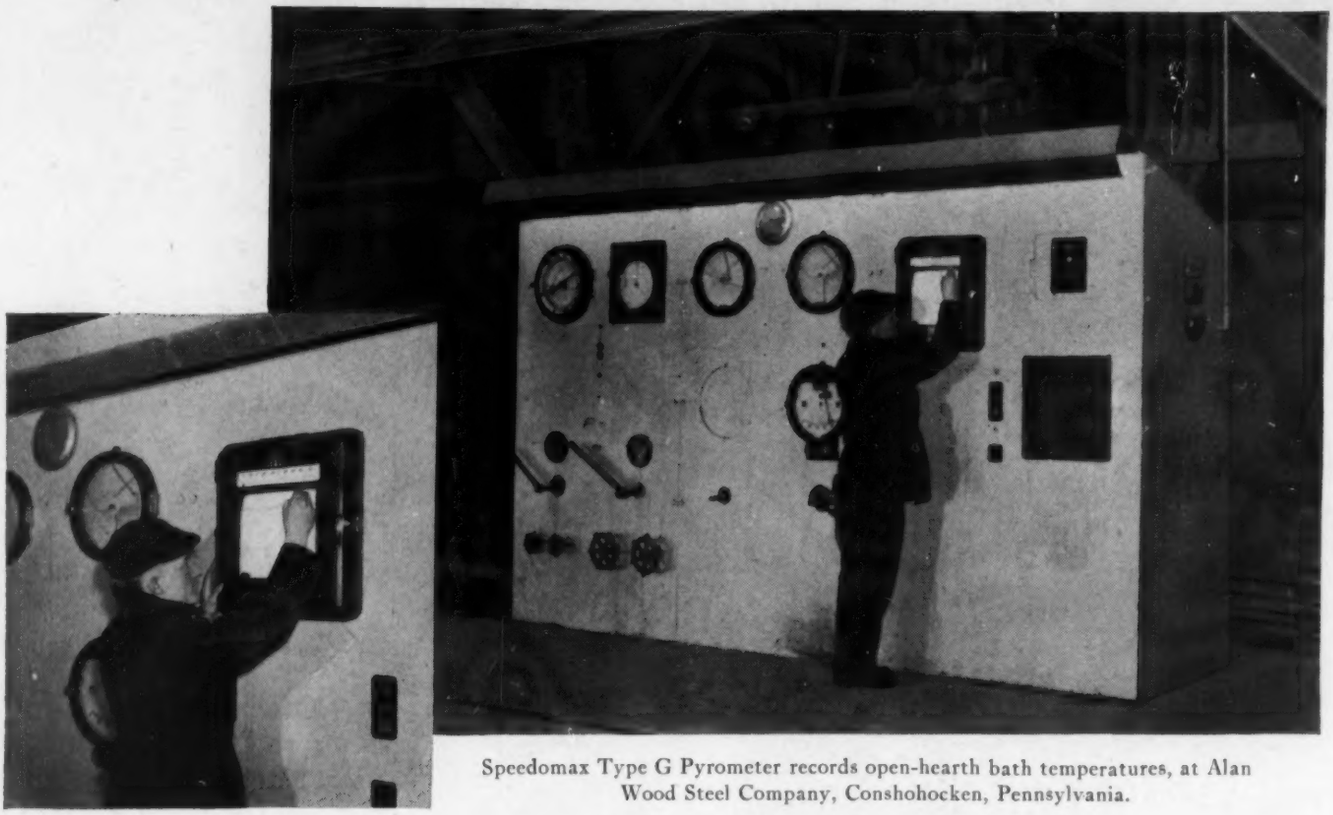

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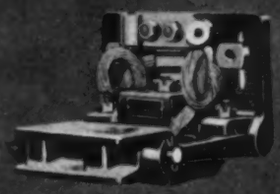

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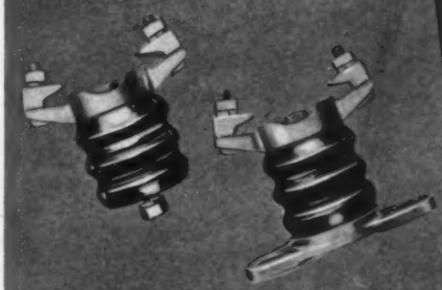

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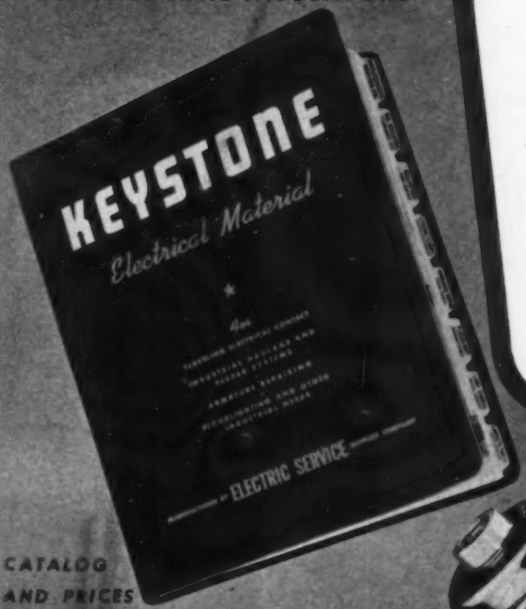

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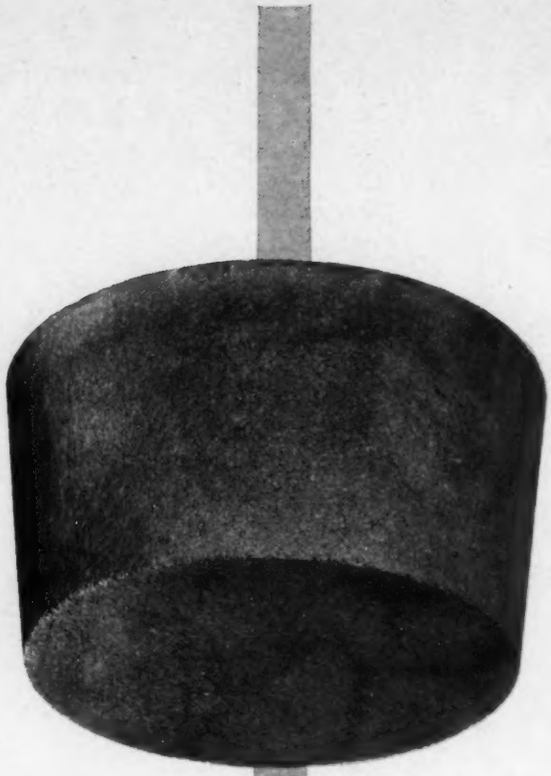

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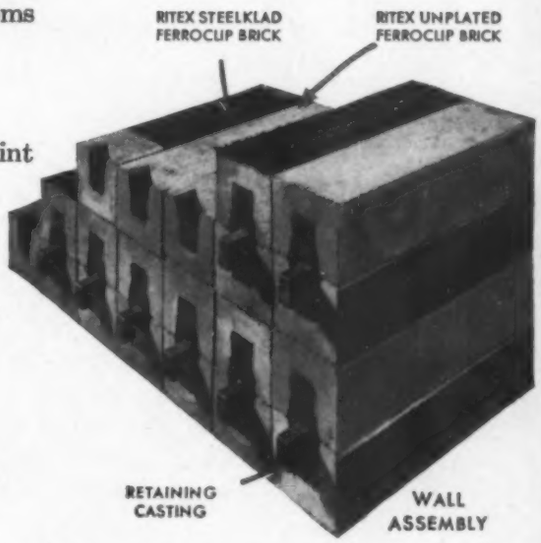

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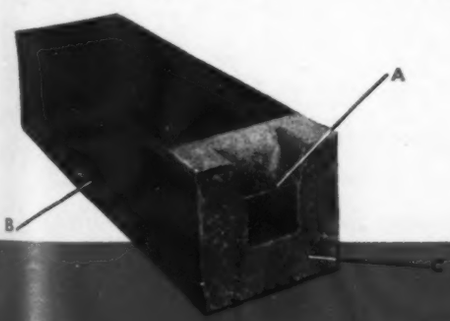

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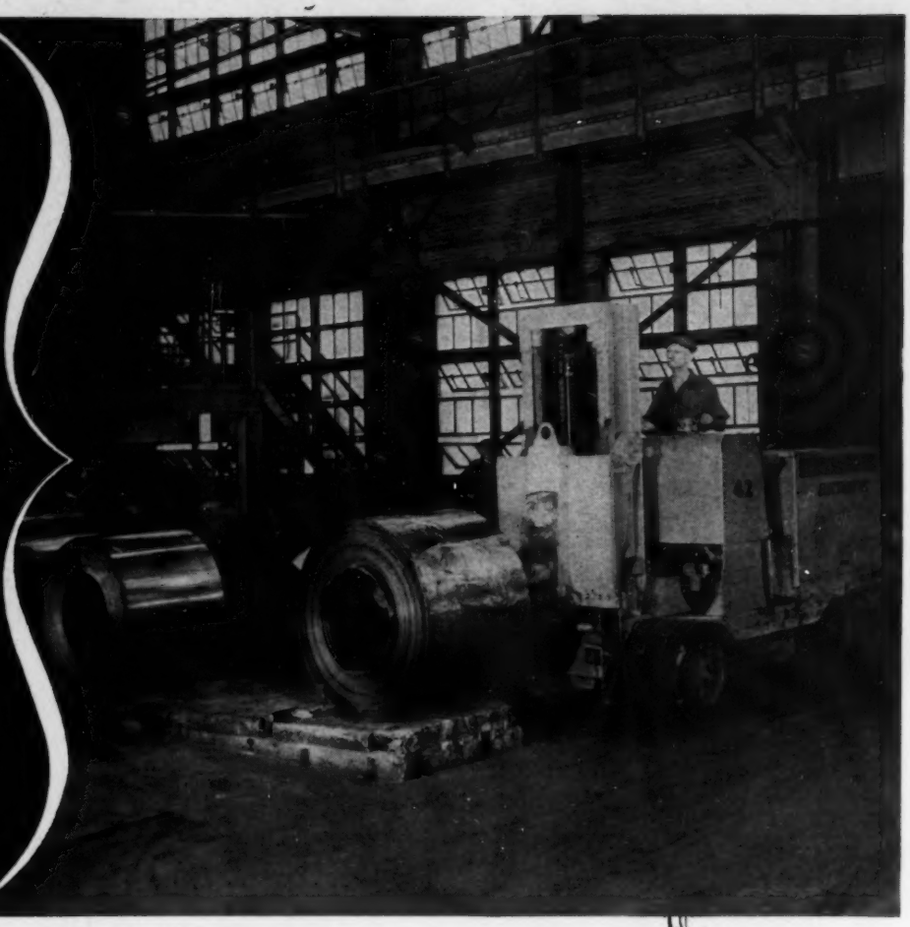

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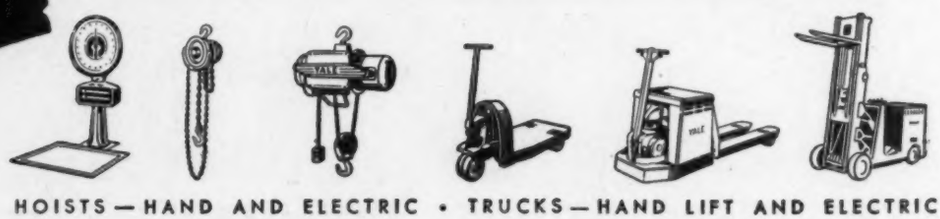

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HEAT PROBLEMS IN THE STEEL INDUSTRY

. . . . the electrical analogy method of experimentation offers a clue to the solution of many heat flow problems in the steel mill which could not be conveniently solved by any other method . . . .

By DR. VICTOR PASCHKIS, Technical Director, Heat and Mass Flow Analyzer Department,
Columbia University, New York, New York

▲ GENERALLY speaking the steel engineer thinks of heat problems in terms of problems of combustion or of means to lower the fuel consumption. There is, however, a great field of heat problems which does not fall into this classification but treats of the flow of heat in solids.

The solution of these problems has as its primary concern the quality and the uniformity of the product and only secondarily is it concerned with fuel economy or combustion. A thorough study of phenomena underlying quality and uniformity is badly lacking, mostly perhaps because of the difficulty of systematic analysis. This difficulty may today be overcome to a considerable extent with modern means of research.

The solution of any problem in industry must frequently depend on the degree of cooperation that exists between specialists in different fields. The list of problems as submitted in this paper is seen entirely from the eyes of the heat flow specialist. It is recognized that in some instances the solution of only the heat flow aspect of a problem is not a complete answer because of other factors, for example those of operation, which may influence the final picture. But this should not detract from the value of knowing the answer to the heat problem; rather it should stimulate a systematic investigation of the other aspects too.

REVIEW OF SOME HEAT FLOW PROBLEMS IN STEEL MILLS

In this section are listed some problems in which the heat flow aspect is of major importance.

1. *Melting furnaces* — The three types of melting furnaces mostly used in steel mills today are the open hearth, the arc furnace and the high frequency induction furnace. In all three types of furnaces a number of heat flow problems occur.

There are three major heat flow problems in connection with the open hearth furnace. The first is that of heat flow in the charge resulting from the passage of hot gases over the surface, and from the radiation from the roof. The problem is essentially one of how fast a mass of broken solids (i.e. the charge), exposed to a high temperature source on one surface and insulated on the other, heat up. This simple statement of the problem is insufficient if the gradual melting is considered. In Figure 1 the shaded area "A" represents a batch of steel. The line "B" represents the roof and the hot gases. Heat transfer occurs in the direction of the arrow "1," and heat loss occurs through the lining "C1" at the bottom and "C2," "C3" at the sides. As soon as the top layer (densely shaded, marked "A") starts to melt, the steel drops into hollow spaces between the lower part of the charge; it may solidify there again and only gradually, as the hollows are filled out, does the final melting occur. One significant result from a better knowledge of the process would be the proper selection of scrap size to be charged in the furnace.

The second problem in connection with open hearth furnaces deals with the regenerator. It has been stated that no two furnaces in the country have a regenerator of similar design. This statement, even if exaggerated, certainly indicates the necessity for clarifying the problem. An attempt to find a mathematical solution has been made in Germany[1], but the mathematical difficulties are so great that the assumptions necessary to obtain a solution almost nullify the value of the work. Heindlhofer and Larsen have studied one problem by means of electric analogy[2], and the author has also done considerable unpublished work along these lines[3]. Among the various factors which influence regenerator design, the following are of particular importance: width of the flue channels, time of reversal, brick thickness and quality, air and gas velocities, and deposits of soot and dirt. A systematic investigation of these factors should lead eventually to a more or less accepted standard practice of regenerator design. Such investigation, even if limited to the simple case of a straight flue regenerator is almost impossible by any of the conventional means of analysis, but it is possible by modern tools of investigation.

The third problem in open hearth furnaces is that of insulation. Temperatures in furnaces and in the regenerators fluctuate. Heat losses with varying inside temperatures are not readily calculated, but should nevertheless be known because they determine the desirable amount of insulation. The conditions are similar, although not identical, with those in heat-treating furnaces subjected to intermittent loads. A reference is made to some publications dealing with heat losses in intermittent operations[4].

Many heat problems occur in arc furnaces. They have

Presented before AISE Annual Convention, Cleveland, Ohio, October 1, 1946.

been described in some detail in a recent paper by the author[5]. Particular mention should be made here of the electrode problem. Consider an element of an electrode. For any element (E) of the electrode, Figure 2, there are two sources of heat income, and heat is expended for two purposes.

The two sources of heat income are the ohmic losses in the element, and the heat conducted from the tip of the electrode (A). The two fields of heat expenditure are radial and axial heat flow (F_R and F_A). The heat balance of element E is indicated by Figure 3. The width of each stream indicates the relative size of the heat flow. For each element, having a different distance L from the tip of the electrode, the magnitude of each of the four streams changes. The sum of the streams (4), plus a correction for the last element determine the total energy loss of the electrode. This loss is determined by the diameter of the electrode. An increase in diameter decreases the ohmic losses but increases the heat flow by conduction from the tip. There is therefore an optimum diameter from the viewpoint of smallest energy losses. This optimum diameter has so far largely been determined empirically. It is known that the maximum rate of energy input to the tip of the electrode is limited by the resistance and inductance of the busses and that this maximum rate is one of the factors determining the output. A lowering of the electrode loss results in the possibility of a higher rate of power led to the bath, and therefore an increased output of the furnace.

Another interesting problem in arc furnaces refers to heat storage in the walls. An energy balance taken for the melting period alone and based solely on the power consumption during that period as a source of heat income, may result in operation efficiency figures larger than one. An explanation is that during a preceding refining period, heat was stored in the furnace walls; this heat is then returned to the charge during the next melting period. The study of this heat storage problem is important because of the problem of wall design. Considerable controversy exists about the possibility and the desirability of insulating the side walls of an arc furnace, and the heat storage in the walls has great importance on the decision in this connection.

One of the main drawbacks of induction furnaces is their low efficiency. In general the efficiency of an induction furnace is considered as being composed of two independent elements: the electrical efficiency and the thermal efficiency. The electrical efficiency is proportional to the ratio of the diameter of the charge to the coil diameter d_2/d_1, Figure 4. The larger this ratio is, the higher is the electric efficiency. Of course a large ratio of these values leaves little space (I) for heat insulation and therefore a large ratio lowers the thermal efficiency. It is obvious that an optimum diameter will exist for which the total loss will be at a minimum. However, this optimum cannot be found by independent consideration of the electrical and heat losses. This will be clear from the following consideration. The heat losses are supplied by the hot metal. Therefore the energy dissipated in the form of heat loss must first be introduced into the charge and this transfer of energy to the charge causes electrical losses. A decrease of the heat losses will therefore cause a greater drop of losses than expressed in the mere amount of Btu saved in heat

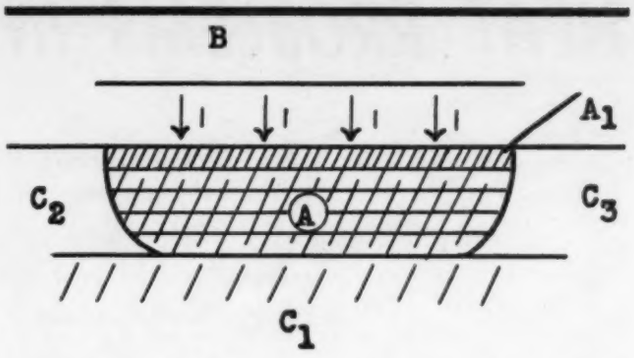


Figure 1 — A schematic diagram showing heat flow in the open hearth furnace.

transfer through the lining. If the optimum wall thickness is calculated first on this consideration, it will become greater than that calculated by the conventional but wrong method of coordinating the two losses as if they were independent of each other.

2. *Ingot solidification* — The solidification of ingots has a definite bearing on the grain structure of the ingot. Uniform rate of solidification results in uniform ingots and elimination of enclosures of dirt.

A study of solidification by observing the temperature drop is difficult because of the extreme difficulties of temperature measurements in liquid steel. Another method of studying solidification is the so-called "bleeding of ingots," consisting in turning over the partly solidified ingot, thus draining the still liquid steel and then measuring the thickness of the solidified wall. Obviously such experiments are difficult, and extremely costly for large ingots. Therefore relatively few data are available, but a great amount of work has been done in mathematical analysis, the results of which are published particularly in English and German literature[6]. All mathematical derivations, however, suffer from the necessity of making rather sweeping assumptions which are only partly justified. The method of analysis described in part three of this paper obviates the necessity for most of these assumptions. Experiments by the electric analogy method have been carried out with considerable success on the solidification of ingots as well as of castings[7].

One of the most baffling phenomena in the solidification of ingots is the formation of the air gap which forms as the ingot contracts. The time of formation and, to a smaller degree, the width of the air gap have particular influence on the process of solidification. Heat

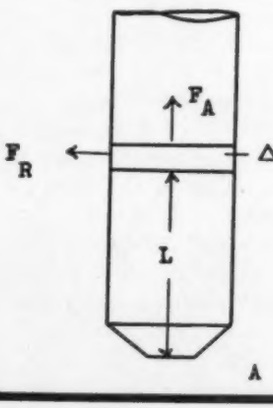


Figure 2 — Heat flow in the electrode occurs radially and longitudinally.

transfer across the air gap takes place by radiation and by conduction, but hardly ever will the air gap be wide enough to allow an appreciable amount of convection. Now, radiation is independent of the width of the air gap and at the high temperatures involved its influence is so much larger than that of conduction that the total influence of the width of the air gap is but small.

With the method of analysis described in the third section, it is possible to represent the thermal resistance of the air gap provided the time of formation of the air gap is known. Certain experiments, which would permit the determination of this time by combining observations in the mill with subsequent analysis in the laboratory, look very promising.

Among the results hoped for is the determination of the influence of the mold wall thickness. The mere statement of a so-called ingot-mold ratio independent of the shape or size of the ingot is probably insufficient, and the effect of different ingot-mold ratios with different sizes and shapes should be determined.

The determination of the correct stripping time is also essential. An unnecessarily long stripping time is wasteful and too short a stripping time is dangerous.

The influences of the degree of superheat on the time of solidification are subject to considerable disagreement and could be conveniently studied.

It would also be interesting to study the mutual influence or the proximity effect; that is, the effect of the distance between two molds on the same car. Such an investigation is quite complicated but should be envisioned as an ultimate step.

3. *Soaking pit* — The time-temperature relationships of the ingot in the soaking pit should next be considered. Depending on the stripping time and the transfer time, the temperature distribution of the ingot at the moment of entrance into the soaking pit will be variable. The desirable time in the pit depends on the desired degree of uniformity and can be determined rationally rather than by trial and error. It should be noted that increasing uniformity means considerable increase of necessary heating time in the pit. In the soaking pit ingots are usually subject to a rather complicated pattern of heat flow. Adjacent ingots influence each other mutually and prevent perfectly uniform flow of gases. But even assuming absolutely uniform temperature of the gases, the temperature rise of various ingots may be different because of the different temperatures at which they are introduced into the pit. Their different temperatures may result in mutual influence. An investigation might start with the ideal condition of an ingot receiving heat uniformly from all sides and analyzing the influence of the heating time on the degree of uniformity which can be reached. A further step might take into consideration the mutual influence of two ingots assuming uniform gas temperature, and finally an attempt might be made at introducing non-uniform gas temperature.

Following the soaking pit operation, the ingots are transferred to the mill, and, in some cases, then to reheating furnaces. The question of cooling during the transfer from the pit is important. It is generally not appreciated to what degree the temperature uniformity is influenced by the cooling of the ingot in the air during the transfer.

4. *Reheating for rolling and heat treating furnaces* —

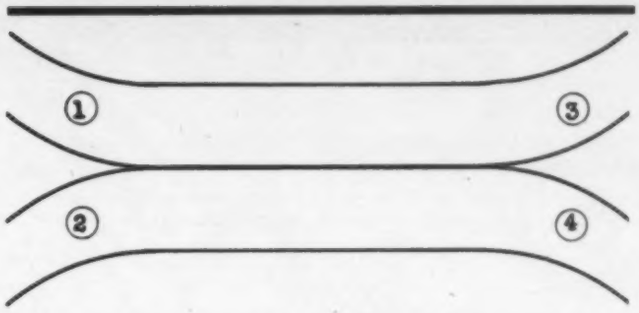


Figure 3 — The energy balance of the electrode is as follows: (1) heat generated in E, (2) heat received from A, (3) heat loss through axial flow, and (4) heat loss through radial flow.

In many respects the heat flow problems in reheat furnaces and in heat treating furnaces (for annealing, hardening, etc.) are similar. The main problem is that of temperature uniformity and necessary heating time. The problem of thermal uniformity is all too often misunderstood. Complete thermal uniformity includes equal final temperatures at all points, equal rate of temperature increase[8], degree F per minute, equal time at temperature for all points in the body. Obviously complete uniformity can never be achieved, because heating (and cooling) is predicated on temperature differences. It is however desirable to determine how closely the complete thermal uniformity is approached. In the heating furnace, ingots are subjected either to heat from the top alone or from top and bottom. Heating from one side (top) alone results in non-uniform temperatures. The degree of non-uniformity should be determined[9] and the desirable space temperature distribution in the furnace, with its influence on the temperature uniformity of the ingots, should be more fully analyzed.

In heat treating furnaces the uniformity problems are of the same general nature as in reheating furnaces but are frequently more complex because of the difficulty involved in evaluating the heat transfer from one piece to the next[10]. In heat treating furnaces a second problem is to be mentioned here, that of heat losses from furnace walls in intermittent operation. The rate of heat losses depends on a number of factors including intermittency, length of period, etc. The rate of heat losses, in turn, is important in selecting the most economic wall thickness. Some studies have been made[11] but a more complete analysis is desirable.

REVIEW OF SOME METHODS OF HEAT FLOW ANALYSIS

Once a heat flow problem is recognized as such, there

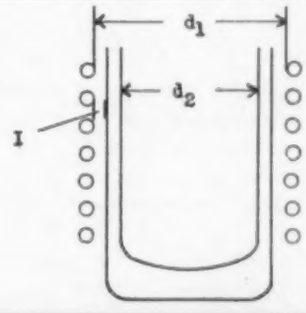


Figure 4 — Electrical and thermal efficiencies run counter to each other as the proportions are changed of a high frequency, induction furnace.

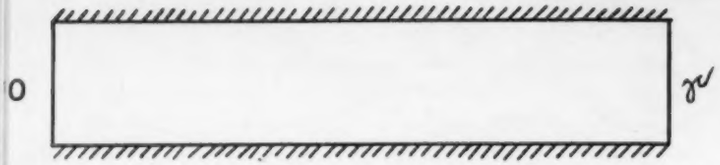


Figure 5 — Sketch of insulated rod.

are several ways of solution. The most obvious is that of direct experimentation, providing for reasonably controlled conditions and then making temperature measurements. That this method is not more widely applied has good reasons; the creation of controlled conditions and the taking of accurate temperature measurements in plants are very difficult and frequently interfere with production. Consequently, the results of many experiments carried out in plants are applicable only to local conditions and cannot be trusted too much.

All other methods have one difficulty in common. They are based on a knowledge of the physical properties of the material involved, and this knowledge is frequently lacking. To what extent this handicap may be overcome will be reviewed later.

One possibility of solving heat flow problems aside from direct experimentations is mathematical analysis. The more or less conventional methods have little practical value because the steel engineer frequently has not the time to develop the necessary differential equations, and if he did have time, the subsequent numerical evaluation would be too lengthy. Special mathematical methods including graphic analysis can be used, but require some skill and experience in operation.

Another method which has shown its usefulness in a number of problems is that of analogies. Basically, two methods can be used, that of hydraulic analogy and that of electric analogy. The latter has been greatly developed and a few remarks with regard to this method may be in place.

As far as a study of transient or cyclic phenomena is concerned, the method has first been published by C. L. Beuken[12]. Based on this method a heat and mass flow analyzer has been designed at Columbia University[13]. The method is based on the fact that the differential equation for heat flow in solids is the same as the differential equation for the flow of electricity in a system with evenly distributed resistances and capacitances. To make the method practically applicable, a method of lumping is introduced; and the body in which heat flow is taking place is considered to be cut into individual sections or lumps. The thermal capacity is considered to be concentrated at the center of each lump, and the resistance to heat flow is considered to be concentrated along the axis of each section.

In the analogy the following magnitudes are equivalent:

Temperature difference . . Voltage (potential difference).
Rate of heat flow . . . . . Current.
Thermal resistance . . . . . Electrical resistance.
Thermal capacitance,
(volume × density
× specific heat) . . . . . Electrical capacitance.

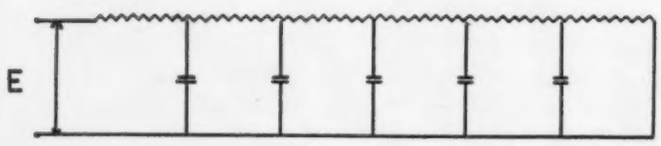
To explain the method, reference is made to Figures 5 and 6. Figure 5 represents a rod, insulated on the sides and exposed to a temperature difference at both ends. Figure 6 is the equivalent electric circuit. In order to arrive at the circuit, the rod is thought of as being divided into sections as shown in the figure, and each section is represented by one resistor and one condenser (capacitance).

By carrying out appropriate electrical measurements, the voltages at different points in the circuit can be found. These are equivalent to the temperatures at corresponding points in the rod. Similarly the currents are various points may be observed, and these are equivalent to the rates of heat flow at the corresponding point in the rod.

Two features in connection with this method are important. First, it is possible to introduce a time ratio in such a manner that the electric experiment is not carried out in the same time as the heat flow operation. It is possible either to stretch or to shrink the time. For example, a very brief heat occurrence, lasting only fractions of a second, may be stretched in the electric experiment to last several minutes. An example of such very short phenomena is the temperature drop in steel during quenching. Another occurrence, for example the solidification of large ingots, which lasts several hours, may be condensed in the electric experiments to last only 15 or 20 minutes. This application of a time scale makes this method extremely powerful. It is possible to study certain phases of a process in great detail and other less important phases in shorter time with great accuracy.

The second aspect is the ease of operation. Once a circuit is set up to represent a certain problem, it is quite easy to change the setting of the resistors and the condensers so as to represent different thermal properties. This can be very helpful in case the thermal properties are not accurately known. It is possible to run the same experiment over several times with slightly varying properties, and thus obtain results for the limits of the practicably possible values of the different properties. Moreover, it is possible to determine which properties are of greatest importance and then concentrate on the determination of these properties. To illustrate what is meant, take the case of the solidification of ingots. The rate of solidification is influenced by the following factors: thermal conductivity, specific heat and density of the liquid as well as of the solidified steel; thermal conductivity, specific heat and density of the mold; time of formation of air gap, air gap resistance and resistance to heat flow between the surface of the mold and the surroundings. It would be very expensive to determine all these properties accurately. It is possible by means of electric analogy

Figure 6 — The electrical characteristics of this circuit are analogous to the thermal characteristics of the rod shown in Figure 5.



to determine which of these properties are of greatest significance in the solidification and then concentrate the efforts on the determination of these most important properties for different alloys. The building upf different circuits for different problems is greatly facilitated by properly arranging the available resistances and capitances, and this has been done as described in various publications[13].

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DISCUSSION

PRESENTED BY

C. J. WYROUGH, Superintendent, Steam Efficiency and Combustion, Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania

VICTOR PASCHKIS, Technical Director, Heat and Mass Flow Analyzer Laboratory, Columbia University, New York, New York

C. J. Wyrough: The solution of all of the problems set forth in the paper we have just heard presents a very formidable task which is highly complicated by the great number of variables involved in all of these problems.

In the design of regenerators the kind of fuel used is a very important factor that should be added to those mentioned by Mr. Paschkis. Furnaces fired with gaseous fuels can use a checker with a smaller opening than is possible on a furnace using tar as the fuel. Regenerators with straight chimney flues work out very nicely with gas fired furnaces, and serve quite well with oil fired furnaces although some operators of oil fired furnaces favor checkers with open sides, and with tar fired furnaces some form of open checkerwork to facilitate cleaning is almost a necessity due to the rapid checker build-up. But that some manner of standardization is desirable is best evidenced by the many changes that are made in checker design, and if records are kept for a sufficiently long period, it is often discovered that these changes operate in circles and eventually the same design is being recommended that had been discarded several years before.

Some of the variables attendant ingot solidification have been mentioned by Mr. Paschkis, the influence of mold wall thickness, stripping time, distance between two molds on the same car. To these can be added the wide variations in atmospheric temperature, frequently amounting to 35 F in a twenty-four hour period, the placement of ingots at the strippers with relation to other ingots already stripped, or waiting to be stripped. There is such as innumerable amount of these uncontrollable variables present in these problems that it would appear difficult to evaluate the other factors with any great degree of accuracy.

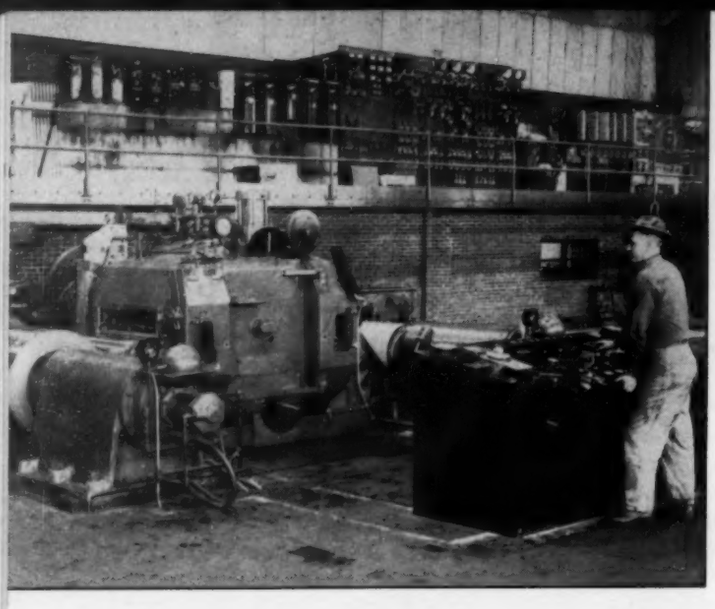
By experimentation it has been determined that much better results are obtained with certain grades of steel by holding it at the pouring platform for a specified time after pouring, and time limits have been established within which it is not permissible to move this steel. Likewise, it has been established that ingot molds of uniform thickness give better results than tapered molds. These facts were established only after long periods of observations, and the development of any new methods which will make it possible to secure such conclusions more quickly will be a great help to the industry.

The application of the new testing technique, described by Mr. Paschkis, to the solution of the problems mentioned in his paper and to the many others in the steel industry awaiting solution will be a most interesting development. The progress being made will be closely watched and, of course, the practical value of the ideas proposed today by Mr. Paschkis will be measured by the results obtained.

Victor Paschkis: Mr. Wyrough is right in his statement that the task of solving the problems mentioned in the paper is a difficult undertaking. He mentions additional variables for the regenerator problem which are of another nature than heat transfer. In the paper it has been recognized that the heat transfer aspect is only one out of many to be considered, and the coordination of results of heat transfer investigations with such items as ease of cleaning regenerators will yield the best design.

Regarding ingot solidification, the writer comments in part again on an influence other than heat transfer, namely the necessity of not moving certain grades of steel while liquid. Such conditions establish limits within which the heat transfer study would have to be made. The fact that many variables of a heat transfer nature, such as closeness of ingots to the stripper, atmospheric changes, etc., make the problem in part more difficult to solve, shows also an increased need for systematic investigation. Only by separating the influences of different variables can it be hoped to come eventually to the total picture.

NEW COMPANY INSTALLS PRECISION STRIP MILL

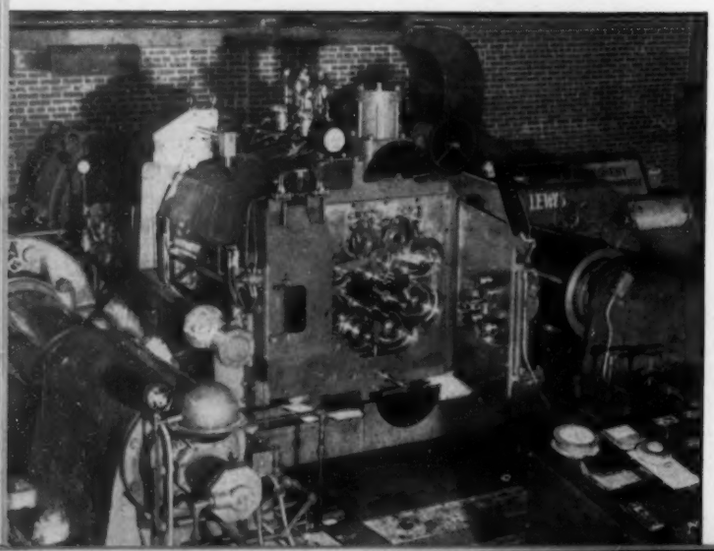


The accuracy inherent in the Sendzimir mill is a result of the clusters of back-up rolls which practically eliminate gage variations due to roll deflection.

A large squaring shear is used to continuously shear rolled and polished stainless steel sheet.

▲

The pulpit controls all synchronized equipment on the 465-foot continuous annealing and pickling line.



▲ WASHINGTON Steel Corporation, a new company formed to produce cold rolled stainless strip and sheets, started operations last month at Washington, Pennsylvania. The plant is located in the property formerly known as Washington Tin Plate Company, comprised of buildings totaling over 125,000 sq ft of floor space.

Under the trade name MicroRold, the new company is planning to produce cold rolled stainless strip and sheet in gauges of 0.004-0.078 in. and in widths up to 36 in. An ultimate output of 1500 tons per month is planned. Hot rolled coils for processing are purchased from various companies.

A Sendzimir mill, 37 in. wide, performs the cold reduction. This mill, a cluster design, uses work rolls 1 7/16 in. in diameter, with each work roll backed up by two intermediate rolls, which are in turn backed up by three secondary intermediate rolls. The secondary intermediate rolls are in turn backed up by four shafts, top and bottom, carrying a number of roller bearings, the outer races of which bear against the secondary intermediate rolls and absorb the transmitted rolling pressure.

The shafts carrying the roller bearings are slightly eccentric, so that by turning these shafts slightly through the action of adjusting screws, the positions of the intermediate rolls, and consequently, of the work rolls, are changed, resulting in a screw-down action whereby gauge of the rolled product may be varied.

The four intermediate rolls (two top and two bottom) are driven through reduction gears and pinions by a 400 hp, 500-1000 rpm d-c motor. Work rolls are driven by the intermediate rolls.

The small diameter of the work roll permits heavy reductions without excessively high pressures, permitting the rolling of light gauges without intermediate processing. High front and back tension in the strip also help to reduce rolling pressures.

The reel on each side of the mill provides entry and exit tension. Since the Sendzimir mill operated under high strip tension, solid mandrels are used instead of the collapsible type to withstand the high stress.

Each reel is driven through reduction gears by a 300 hp d-c motor. Coils up to 8000 lb in weight may be handled.

The rigidity offered by the relatively small size of the Sendzimir mill housing, plus a design that tends to compensate for deflections, results in a precision mill that will produce the accurate uniformity of gauge so desirable in strip products and so necessary in the light gauges in which the company proposes to specialize.

Rolling speed through the Sendzimir mill ranges 220-440 fpm. Stainless strip can be reduced from 0.135

in. to 0.010 in. in eight passes without any intermediate heat treatment.

A continuously circulated flood of oil is played over the strip and the mill rolls, absorbing the heat generated by reduction of the strip.

Strip tension and oil pressure are interlocked with the mill and reel drives so that changes in either condition will shut down the mill.

Heat treating and pickling are performed in a single processing line extending 465 ft in length. Strip is fed from a pay-off reel and passes first through a direct-fired furnace 40 ft long. Natural gas, introduced through burners spaced along the top and bottom of each side of the furnace, maintains the furnace temperature at any point to which the automatic control is set. Temperatures of the order of 2100 F are usual.

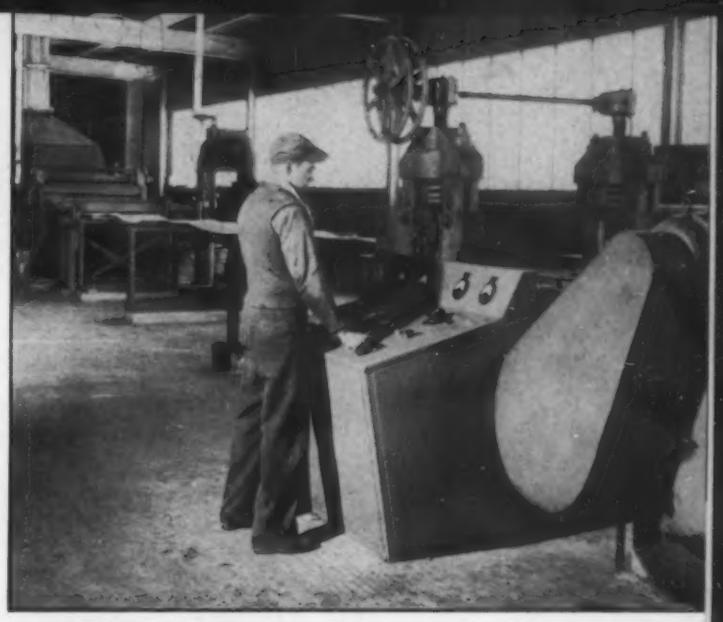
Following the furnace are two pickling tanks 40 ft long and a 20 ft wash tank. A scrubber and dryer are next in line, followed by pinch rolls, a cropping shear and a recoiling reel. Space has been left between the exit end of the furnace and the pickling tanks to permit the future installation of a payoff reel so that the pickling unit can be used independently of the furnace.

The processing line is capable of handling 4 tons per hour.

When product specifications require, the strip may be given a temper pass in a two-high 22 in. × 40 in. skin pass mill. The rolls of this unit are driven through a reduction gear and pinion stand by a 250 hp d-c motor, while each reel is driven by a 75 hp d-c motor. These motors receive power from a motor-generator set driven by a synchronous motor.

Each reel is equipped with a paper reel so that the paper wound between each coil layer is rerolled and reclaimed on the entry side of the mill, while another roll of paper is payed off between each coil layer on the exit side of the mill.

In the finishing department is a leveling and shearing unit to flatten the strip and cut it into sheet lengths as desired.

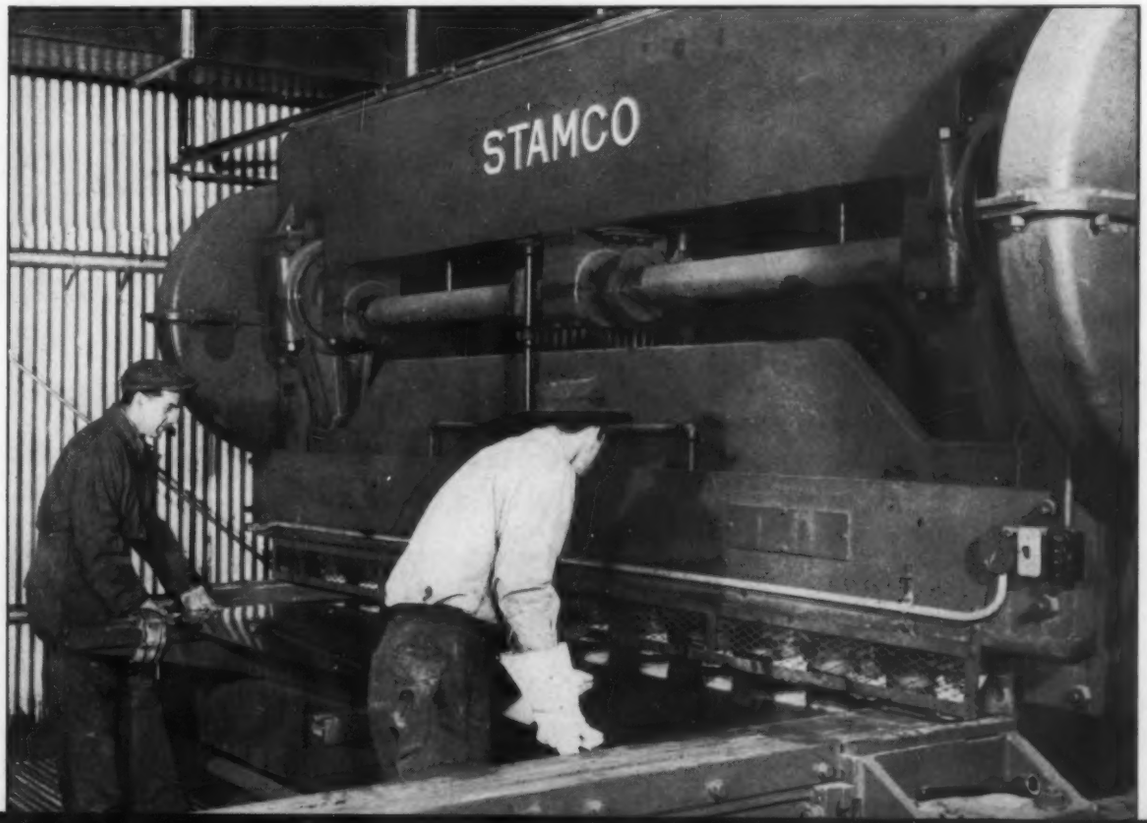


The Sendzimir cold rolling mill is shown rolling its first coil or MicroRold stainless steel strip.

Sheets may be polished on a belt polishing machine of planer-bed design. Various finishes may be given the sheet by changing the nature of the polishing agent with which the belt is coated. Sheets up to 14 ft in length can be polished.

A 250 ton stretcher leveler, capable of flattening sheets up to 0.125 in. thick, 60 in. wide, and 243 in. long, is also provided, as well as a slitting machine that can make up to six cuts on 0.083 in. strip at a speed of 300 fpm. Industrial trucks are used to handle coils from one step to the next throughout the process.

In a service shop adjoining the main mill building are housed a gas-fired vertical fire-tube boiler supplying steam for processing and heating, a roll grinder, an air compressor, and maintenance shop facilities.



A polishing crew polishes and inspects stainless steel sheet.

BUILT BY MORGAN Engineering

MORGAN 600-TON MOTOR DRIVEN STRUCTURAL SHEAR

Illustrated is a Morgan 600-Ton Motor Driven Structural Shear for shearing products from a Morgan 29″ and 23″ Rail and Structural Mill. It will shear up to 4½″ x 4½″ Billets and 4½″ Rounds; Eye Beams and Channels up to 15″; a full line of Angles with equal and unequal legs up to 8″ x 8″; also Fish and Tie Plates.

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NEWS SUPPLEMENT MAY, 1947

Equipment
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Iron AND Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

OPERATING DATA ON THE USE OF OXYGEN IN OPEN HEARTH FURNACES

By J. J. GOLDEN, Gary Works

Carnegie-Illinois Steel Corporation

Gary, Indiana

▲ Within recent months, the most widely-discussed topic among open-hearth operators has been the use of oxygen in open-hearth furnaces. A study of the features of the various types of burners used at the three plants covered by this summary indicates that all are using modifications of their own standard combination oil and coke-oven-gas burners. From a combustion standpoint, the most important difference in the various types appears to be the wide variation in the areas of the oxygen outlets, which results in appreciable differences in oxygen velocity at any given rate of input. Inasmuch as the input rate and the velocity, together with the total time used, determine the amount of oxygen used, it is evident that careful consideration must be given to attaining the optimum oxygen velocity and flow in order to achieve the maximum savings in time and fuel.

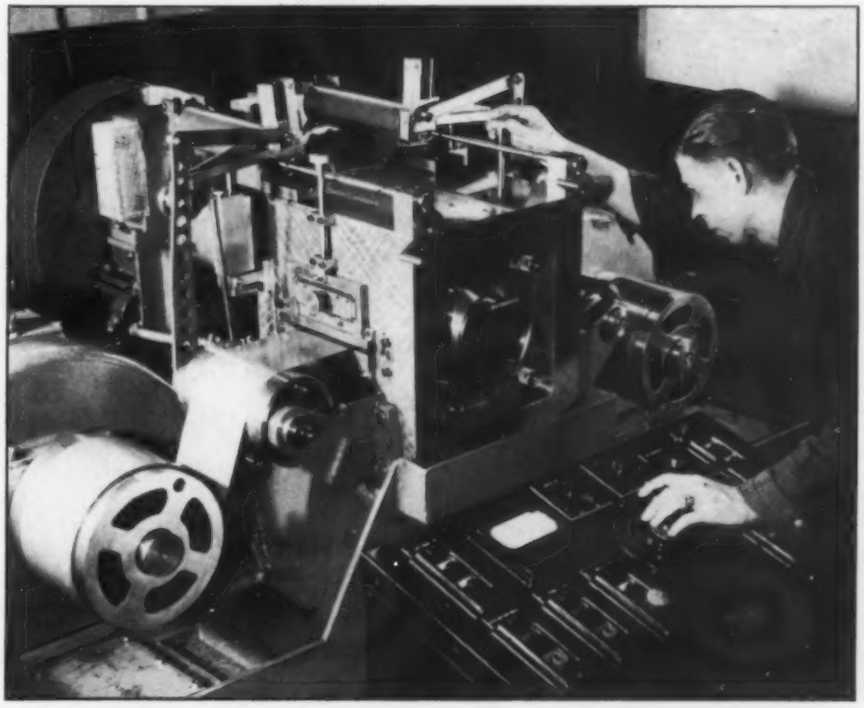
From the operating data shown in the accompanying table, it appears that the greatest saving in time and fuel was obtained with the low-velocity burner used at Plant C. In this case, the total oxygen consumption is considerably higher than with any of the high-velocity burners. It is doubtful whether the increased savings resulting from the use of such a high volume of oxygen is in proportion to the increased oxygen cost.

From the data shown for plants where various types of charges are used, the savings in time and fuel decrease as the percentage of hot metal in the charge increases. It is probable that with hot metal charges over 60 per cent of the savings would not be sufficient to warrant the use of oxygen.

During the course of our experiments, measurements of flame radiation intensities were taken by members of our research staff. Although the data obtained was only on a few heats' it is evident that, with oxygen-enriched air, high luminosity in the first and second doors indicates fairly

Condensation of a paper presented before Open-Hearth Conference of the American Institute of Mining and Metallurgical Engineers, Cincinnati, Ohio, April 21-23, 1947.

MINIATURE MILL ROLLS METAL PAPER THIN

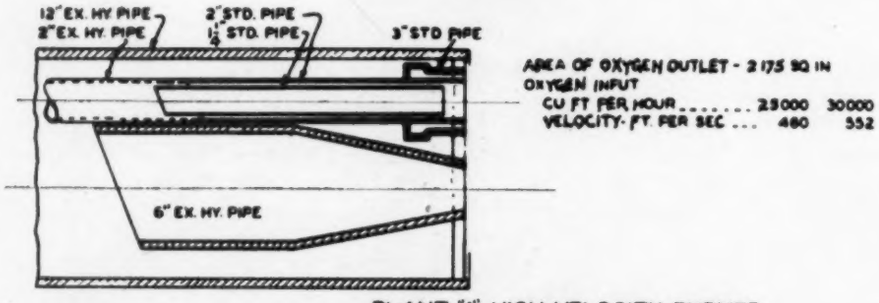


A 100-foot length of metal twice as thick as a calling card can be rolled into a mile-long strip thinner than tissue paper by this miniature rolling mill at the Westinghouse Research Laboratories. Here operator Ralph Darby adjusts the tension on a strip of magnetic alloy as it is being rolled. To roll metals, the strip is wound around the two 12-inch reels on either side of the roll mechanism which is enclosed in the square box-like section. The strip then is pulled back and forth at speeds up to 200 feet a minute. About seven round trips are required to squeeze a strip to a thinness of 1–2000th of an inch.

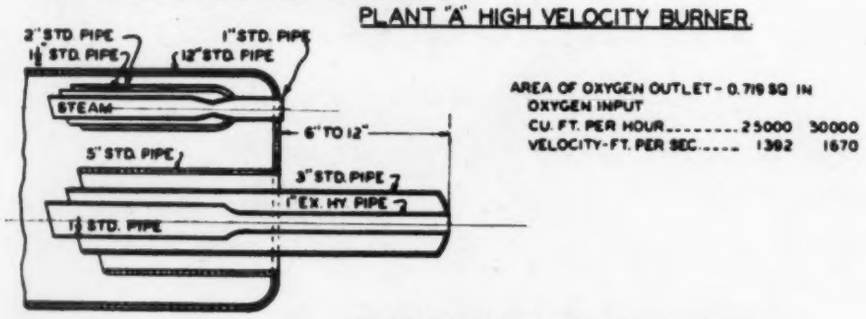
OPERATING DATA FOR OPEN-HEARTH FURNACES USING OXYGEN-ENRICHED COMBUSTION AIR

Plant	Number of Heats	Type of charge, % hot metal	Oxygen input		Per cent savings	
			Cu ft/hr (thousands)	Cu ft/ton	Time	Fuel
A	10	45	25	468	21.7	15.2
	11	45	30	525	17.6	6.5
	10	65	25	369	9.6	2.7
	10	65	30	386	2.8	—5.3
B	4	0	9–18	684	22.6	18.7
	4	55	9–18	326	24.1	11.2
	7	70	9–24	369	14.8	6.8
C	5	40	30–60	746	30.0	17.0

COMBINATION BURNERS EQUIPPED WITH OXYGEN OUTLETS


12" EX. HY PIPE
2" EX. HY. PIPE
2" STD. PIPE
1½" STD. PIPE
3" STD PIPE
6" EX. HY. PIPE
AREA OF OXYGEN OUTLET - 2.175 SQ IN
OXYGEN INPUT
CU FT PER HOUR 25000 30000
VELOCITY- FT. PER SEC ... 460 552

PLANT "A" HIGH VELOCITY BURNER



PLANT "B" HIGH VELOCITY BURNER

10" STD. PIPE
6" STD. PIPE
1½" STD. PIPE
AREA OF OXYGEN OUTLET - 26.056 SQ IN.
OXYGEN INPUT
CU FT PER HOUR 25000 30000
VELOCITY-FT PER SEC 38 46

PLANT "C" LOW VELOCITY BURNER.

complete combustion taking place in this zone, while on the outgoing end of the furnace the flame radiation with oxygen-enriched air is lower than with normal combustion.

At the present time, it appears that the savings in time and fuel resulting from the use of the oxygen lance for removing carbon from the bath are almost as great as the savings from using oxygen-enriched combustion air, with a much lower oxygen consumption; and further experiments may show that, in the long run, the oxygen lance might be the more economical of the two methods.

1944 TRANSPORT COSTS WERE ⅛ OF SALES REVENUE

▲ The transportation charges on the iron and steel industry's raw materials and finished products during 1944, the year of record steel production, were $872,515,000, according to a special study recently completed by the American Iron and Steel Institute. That amount was equivalent to one-eighth of the sales revenue of the entire iron and steel industry in that year. It was more than four times the net earnings of the industry.

More than 40 per cent of the total represented transportation charges on products leaving furnaces and mills, by rail, water or truck. The outgoing shipments accounted for $364,118,000 of the transportation bill.

The remainder represented the cost of bringing into the mills and furnaces huge quantities of raw materials consumed in iron and steel production, as well as other supplies needed for operations. The inbound freight charges were $508,397,000. In that year the industry consumed approximately 100 million tons of iron ore, 95 million tons of coal, two billion gallons of fuel oil, and 17 million tons of purchased scrap, among other materials.

The study made by the American Iron and Steel Institute was confined to the iron and steel industry proper and was not intended to include shipments of subsidiaries engaged in other activities. Freight charges on interplant shipments are included, however.

In 1945, transportation charges totaled $773,408,000, of which 40 per cent covered outgoing products.

BABCOCK & WILCOX SPENDS $500,000 ON RENOVATION

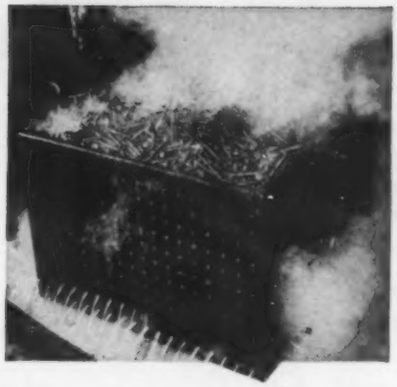
▲ Complete renovation of the grey iron foundry of Babcock and Wilcox Company's plant at Barberton, Ohio, at a cost of more than half a million dollars was announced by company officials. The renovation will include improvements to the building as well as machinery replacements and new

SHEET • BAR • ROD • FLAT • ANGLE • HALF-ROUND • HEX • WIRE • ROUND • SHEET •

How shall I Use Monel To Make the Best Pickling Basket?

There are as many answers as there are standard mill forms of Monel*
COME ALONG AND SEE WHY . . . .

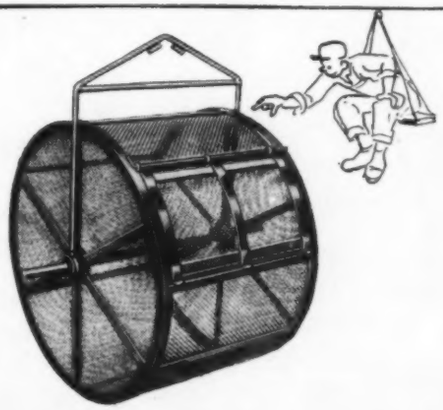
SHEET • BAR • ROD • FLAT • ANGLE • HALF-ROUND • HEX • WIRE • ROUND • SHEET •



1. HERE'S A 307-POUND WELDED BASKET of perforated Monel* sheet. Capacity 2,500 pounds of bolts —10% more than the same size wood basket it replaced. Sharp edges can't chew into Monel. Metal construction gives easy acid flow and prevents uneven pickling.

2. NEXT, A SIMPLE AND STURDY BASKET. Made entirely of corrosion-resistant Monel bar, it was welded by ordinary shop methods. The pin at top center is for hooking onto an overhead conveyor. Side index plates lock into the conveyor when the basket is carried. With a tensile strength of 80-95,000 psi, hot rolled Monel bar is a wise—and safe—choice for a job like this.

3. A COMBINATION OF THREE FORMS of Monel—screen, sheet and bar. This revolving basket weighs 220 pounds, and has a capacity of more than 500. The unique top fastening permits fast and *complete* dumping. Because of Monel's toughness and ductility, a basket like this stays in service long after others have hit the scrap heap.



4. STILL ANOTHER combination, this time of Monel angles and flats, welded together and covered with Monel wire cloth. Hanger and shaft are Monel rod. In all forms, Monel provides high resistance to pickling solutions commonly used by steel mills.

5. SMALL PARTS won't hop out of this all-Monel basket. *They're locked in.* The basket lid is easily removed for loading and unloading.

*Reg. U. S. Pat. Off.

Whether you pickle bulky hollow ware, heavy forgings or small stampings, it's easy to build strong, long-lasting baskets that exactly meet your needs.

Use standard mill forms of

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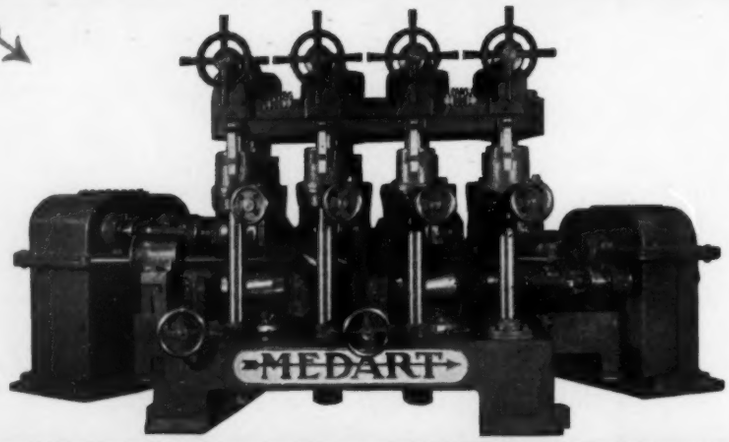
Monel* INCO TRADE MARK

MEDART MULTICYCLE
PIPE AND TUBE STRAIGHTENING MACHINE

"6 in 1"
SIX POINTS OF SUPERIORITY IN ONE

1. MULTICYCLE STRAIGHTENING—Two bending rolls impose duplex straightening cycles on workpiece insuring end to end straightness.
2. POSITIVE AND SYNCHRONIZED FEED—All four feed rolls are driven insuring positive synchronized feed and torque balanced around neutral axis of workpiece.
3. THE WORKPIECE LEVEL—Maintains one feeding level for all sizes of pipes or tubes—eliminates need of adjustable entry and delivery tables.
4. NO GUIDES—Horizontal position of the six rolls with balanced torque eliminates requirement for guides.
5. SINGLE MOTOR—All four driven rolls powered from a single motor, for synchronization and economy.
6. NO BEVEL GEARS—All gears enclosed in cases and running in oil, for sure trouble free operation.

"Patents make Jobs"



MANUFACTURING ENGINEERS OF COMPLETE TRANSMISSION EQUIPMENT AND SPECIALIZED MACHINERY

MEDART

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equipment. Officials predicted that when the program is completed working conditions at the foundry will be comparable to those in any other type shop. In addition, it will make the foundry as modern as any in the industry and increase its capacity.

The program, designed and carried out by the staff engineering department, is part of the recently announced improvement program of the company, though its cost is in addition to the $1,500,000 appropriated for the modernization of the plant. It represents the largest single amount to be spent on any one shop. The program, already in progress, will be carried out without interrupting production and will be completed this year.

New equipment in the foundry will include machinery for mechanically charging the cupola, cleaning equipment, mold and core drying ovens, and a heat treating furnace. The existing melting equipment will be altered and a new cupola furnace installed. A comprehensive dust collection system will be set up and all dust, heat and fumes removed at their source.

The largest individual expenditure for machinery is for a complete sand conditioning system, so that all sand will be handled mechanically. The molding sand will be prepared in a sand treating apparatus for accurate control, and will be stored in overhead hoppers. The most modern type of molding and core-making equipment will be installed. Continuous type conveying equipment will be used to transport the molds from the molding stations to the pouring and cleaning areas.

PROPOSE MODERNIZATION FOR ARGENTINE STEEL

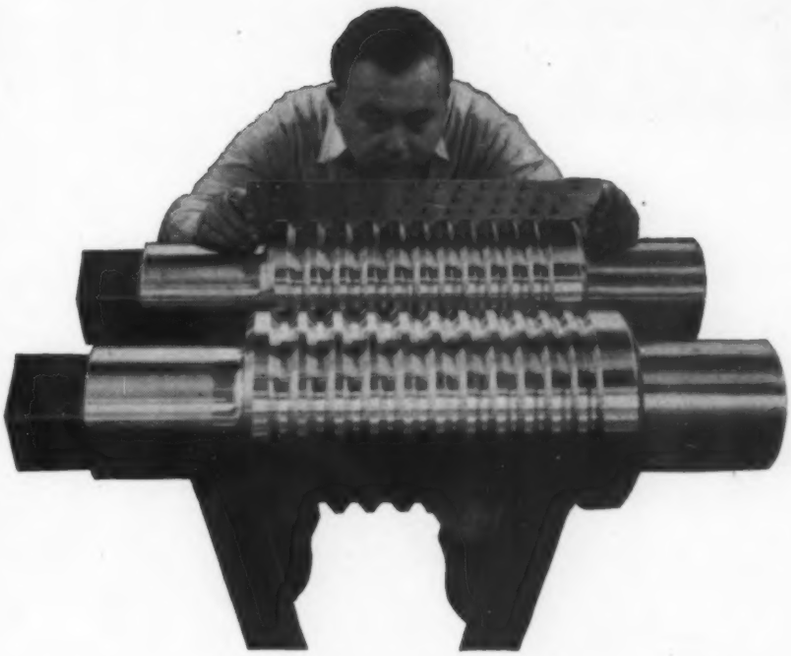
▲ A proposed program for injecting North American industrialization techniques into development of a steel industry in Argentina, was disclosed recently by G. D. Thompson, president and chairman of the board of the Pittsburgh Steel Foundry Corporation.

Mr. Thompson, who recently returned from the South American country where he studied the possibilities of building a steel mill there, declared, "there is no reason why Argentina cannot increase its production of finished steel products."

Two engineers of the Pittsburgh

YOU CAN BANK ON THESE ROLLS

Rolling sheet or strip . . . steels . . . precious metals . . . copper . . . aluminum? Count on Midvale for the right roll for your purpose, whatever it may be. Midvale hardened and ground forged steel rolls are manufactured to meet the specific requirements of our customers. They're custom-made by men accustomed to problems of analysis, hardness, finish, special grinding, etc.—men who have the best of equipment and unusual skill. Forged rolls are a Midvale specialty. They are worthy of your confidence.



THE MIDVALE COMPANY • NICETOWN • PHILADELPHIA

OFFICES: NEW YORK • CHICAGO • PITTSBURGH
WASHINGTON • CLEVELAND • SAN FRANCISCO

MIDVALE
Custom Steel Makers to Industry

STAINLESS AND TOOL STEEL BARS
•
CORROSION AND HEAT RESISTING CASTINGS
•
FORGINGS AND RINGS

Steel Foundry Corporation, Roy J. Leckrone and Louis LaRocca, remained in the Argentine to discuss further the matter with responsible government officials.

The foundry and machine company president declared that his firm would be able to build a steel rolling mill in Argentina which would be producing within 18 months after the start of construction.

"Argentina has the man power and the raw materials are available with which to increase substantially her production," Mr. Thompson said.

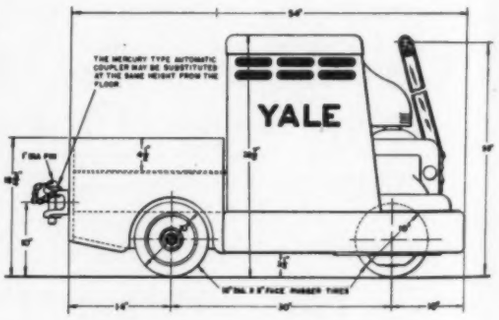
Mr. Thompson explained that the basic steel would be produced by the Government and sold to finishing mills in ingot or billet form. He said he felt Pittsburgh Steel Foundry was well equipped to build the rolling mill equipment which will be required for the program.

The steel industrialist said his plan called for the selection of 25 or more young Argentine steel men who would be brought to Pittsburgh for training in North American techniques. They would work and live with an equal number of young men from the Pittsburgh Steel Foundry, he said, exchanging ideas and languages throughout their indoctrination period.

WORK SAVER POWER TRUCK FOR INSIDE TRANSPORT

▲ In the middle range between hand-drawn equipment and heavy-duty powered trucks, another need in modern materials handling has been met with an intra-plant towing unit in which electric storage battery power does the hauling but the operator guides, maneuvers and walks the load. Introduced by Yale and Towne Manufacturing Company, the new device is called the worksaver tractor, because its power plant, control and handling are of the same type and design as characterize the worksaver lift trucks (both pallet and skid models) and worksaver high-lift units which have been making materials handling news since the war.

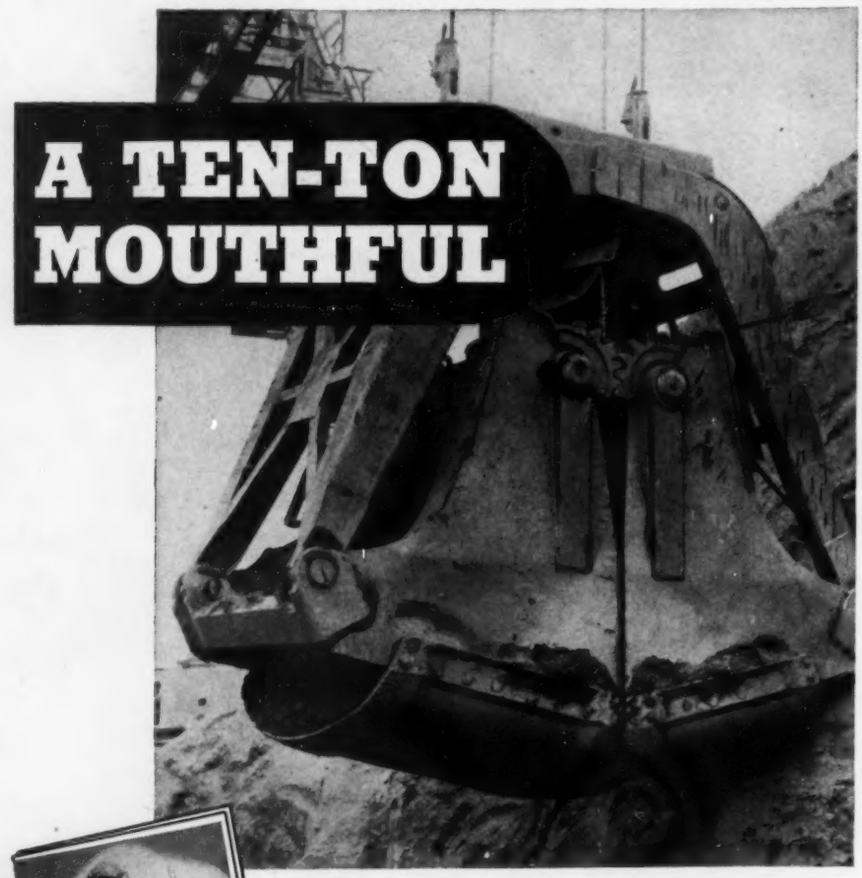
The unit has ample power for hauling heavy trailer loads. Its three wheels are all 10 in. in diameter with



The operator guides and maneuvers this small battery-powered truck.

5 in. rubber tires for full traction and smooth pulling over rugged plant floors and yards. With only 30 in. between rear and forward axles, extremely short turning radii are a feature.

Principal use of the new unit is expected to be for inside-plant transportation of loads which are, at once, too heavy for manual pushing and too ungainly in shape to be handled on platform-type or fork-type appa-



● *It's easy to select your bucket from Catalog No. 2059... write for it.*

Ore handling is no "problem" when your trolley is equipped with a 4-rope bucket of Blaw-Knox design. They're built for fast work and long wear. Alloy steel is used generously and, except for wearing parts, they are of welded construction throughout. There is a wide range of 4-rope models up to 25 tons capacity for wet ores, dry ores and river-rail coal transfer.

BLAW-KNOX DIVISION
OF BLAW-KNOX COMPANY
2040 Farmers Bank Bldg., Pittsburgh 22, Pa.

BLAW-KNOX CLAMSHELL BUCKETS

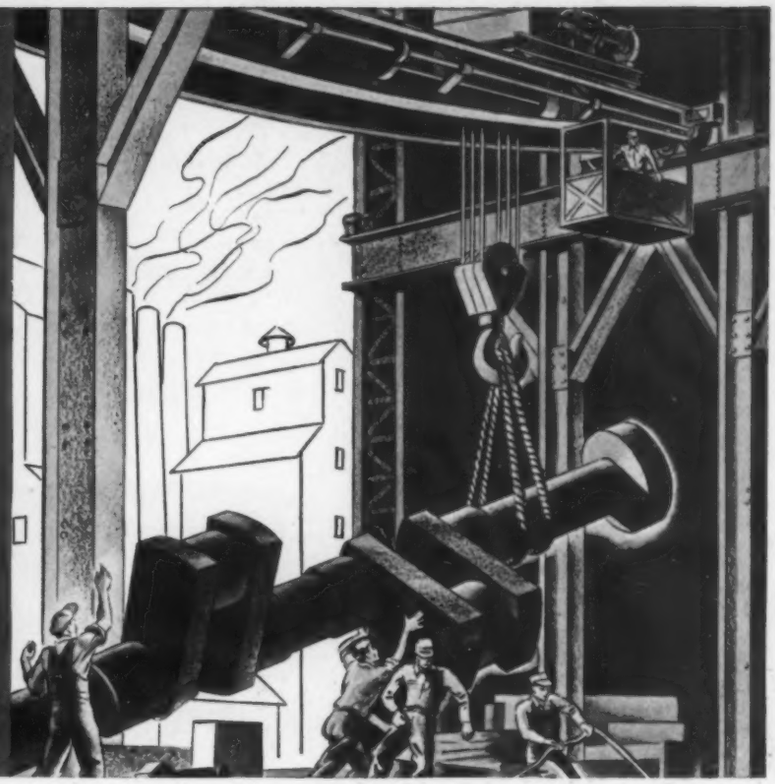
for Cranes--

as well as for your car

Hydraulic Brakes are Best

only **Wagner**

HYDRAULIC CRANE BRIDGE BRAKES give you these *Features*



• Two Types—Four Sizes—Cover the Field

Wagner hydraulic brakes for overhead traveling cranes and other industrial equipment are built with or without parking attachment, in four sizes that cover the entire range of bridge brake applications—light industrial cranes, high speed steel mill cranes, even the largest steel mill ladle crane.

• The New Remote Control Bleeder—

Makes bleeding the hydraulic system a "one-man one-minute" job. Keeps lines full of fluid, maintains peak braking efficiency . . . solves problem of ladle crane applications.

• The New Self-Centering Design

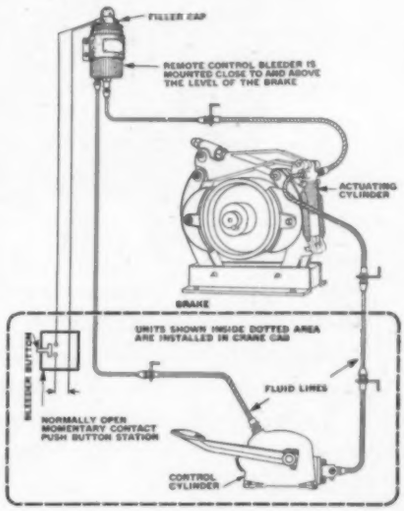
Assures equal clearance of both brake shoes, prevents brake shoe drag. Other advantages include: power failure braking . . . one-point shoe adjustment . . . 200% emergency torque . . . grease fittings for lubrication . . . non-scoring, easily replaced molded lining blocks.

• New Systems Easy to Install

If your cranes are not equipped with Wagner hydraulic brakes, let one of our field engineers show you how simple it is to install the modern system you need. All Wagner systems now include the remote control bleeder.

• Old Systems Easily Modernized

You can bring your present Wagner system up-to-date with our complete-to-the-last fitting conversion kits. You can change your old solenoid-controlled HM brake to the new, compact hydraulic-released type; you can convert a type H brake to an HM; and you can easily add the new remote control bleeder to any Wagner system. Write for Bulletin IU-186 on Wagner Industrial Brakes. Wagner Electric Corporation, 6483 Plymouth Avenue, St. Louis 14, Mo. U. S. A.

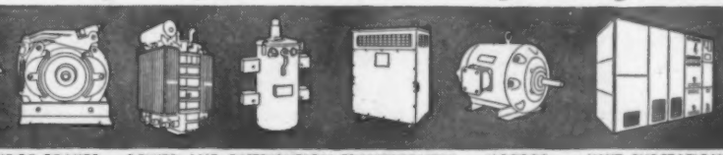

FILLER CAP
REMOTE CONTROL BLEEDER IS MOUNTED CLOSE TO AND ABOVE THE LEVEL OF THE BRAKE
ACTUATING CYLINDER
BRAKE
UNITS SHOWN INSIDE DOTTED AREA ARE INSTALLED IN CRANE CAB
BLEEDER BUTTON
FLUID LINES
NORMALLY OPEN MOMENTARY CONTACT PUSH BUTTON STATION
CONTROL CYLINDER

Wagner Electric Corporation

EST. WE 1891

147-S

Consult Wagner Engineers on all Crane-Bridge Braking Problems



BRIDGE BRAKES • POWER AND DISTRIBUTION TRANSFORMERS • MOTORS • UNIT SUBSTATIONS

ELECTRICAL AND AUTOMOTIVE PRODUCTS

ratus. Bar stock is a typical load, and is handled on dollies or carts, generally home-made and drawn by chains attached to the coupling.

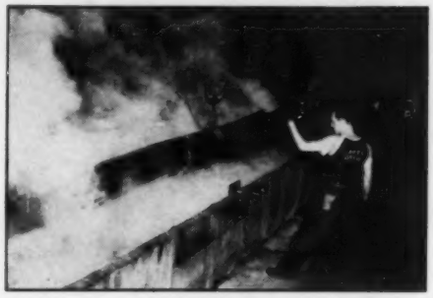
START PRODUCTION ON NEW MERCURY SWITCH

▲ A new mercury switch, capable of handling almost any switching job, has been developed by the Minneapolis-Honeywell Regulator Company.

Less than an inch and a half long, the new switch is rated at one ampere for 115 volts, a-c. Simple in design, dependable and economical in cost, it will save space in switch action mechanisms. The new device, one of several hundred different models made by Honeywell, is actuated by a snap tilt of 12 degrees using a single pole, single throw action.

Production on the new switch has been started and large-scale deliveries scheduled for later in the spring.

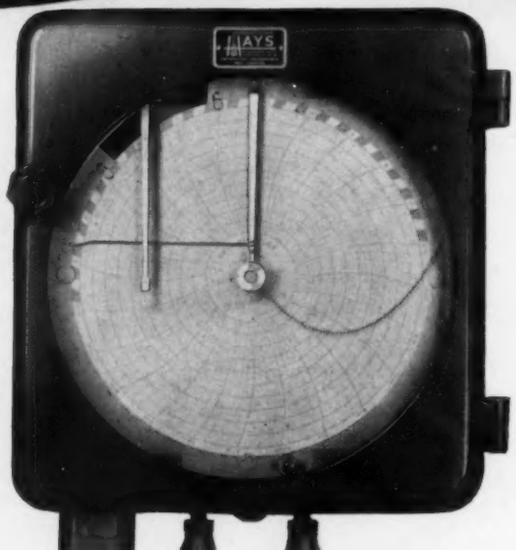
PICKLING SLING USES WIRE MESH CONSTRUCTION



A new type pickling sling has been developed especially for the handling of thin wall tubing in the pickling bath. A product of the Cambridge Wire Cloth Company, it can be used for rod and bar stock as well as tubing. The sling is of mesh construction with flat, even surfaces that do not protrude to collapse the tubing or scratch the finish. It can be placed around the tubing and hooked into a hoist in one operation. The sling is made in any desired length or width of Monel, Inconel, or other materials to resist the corrosive action of the pickling solution, and is capable of handling 5 tons of stock for pickling.

A Practical Means TO CLOSER QUALITY CONTROL

The HAYS "OT" Pressure Recorder



THIS dependable instrument is proving itself invaluable to the steel industry . . for maintaining proper atmospheres in soaking units, annealing furnaces, open hearth furnaces, slab mills, and any place where an accurate record of draft, pressure or differentials is required.

You get an errorless record of two draft values, two pressure values, two differential values, or any combination of two of those values.

A good many new and modernized open hearth installations are equipped with Hays Series "OT" Pressure Recorders . . . as a simple, dependable, practical means to closer quality control.

Step 1 toward getting the benefits of this modern quality control is to get the facts about it. Bulletin 43-586 tells them . . . better send for it.

The HAYS CORPORATION
SINCE 1901 COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA U.S.A.

CO INDICATOR WILL SAVE THOUSANDS OF LIVES

▲ Thousands of people die either directly or indirectly of carbon monoxide poisoning each year. By the use of a secret gadget developed and manufactured during the war by the National Bureau of Standards, many lives can be saved. This carbon monoxide indicator is used for "the rapid determination of infinitesimal" amounts of carbon monoxide in the air. It is the most sensitive instrument of its kind known to science. The detector is about the size of a pencil and was used extensively during the war to detect poisonous fumes in plane cockpits, tanks, etc. The indicator will detect and closely estimate less than 1 part of carbon monoxide per 500 million parts of air, which allows a big safety factor because it takes about one part of carbon monoxide in 10,000 parts of air to affect the human system. Field use requires only a small, inexpensive apparatus without maintenance problems, and involves procedures so

(*Please turn to page 108*)

REDUCE CRANE OPERATING HAZARDS

Typical arrangement of DRAVO CRANE CAB COOLER on Soaking Pit Crane.

DRAVO CRANE CAB COOLER provides complete air conditioning functions, — cooling, dehumidifying, filtering, air circulating, fume-removing, winter heating.

Eliminate Heat-Fatigue **and** *Fume-Nuisance*

Crane cab air conditioning reduces operating hazards in soaking pit and other hot metal crane installations. Operators in air conditioned crane cabs are protected from fatigue due to extreme temperatures and from the physical discomfort brought on by annoying fumes.

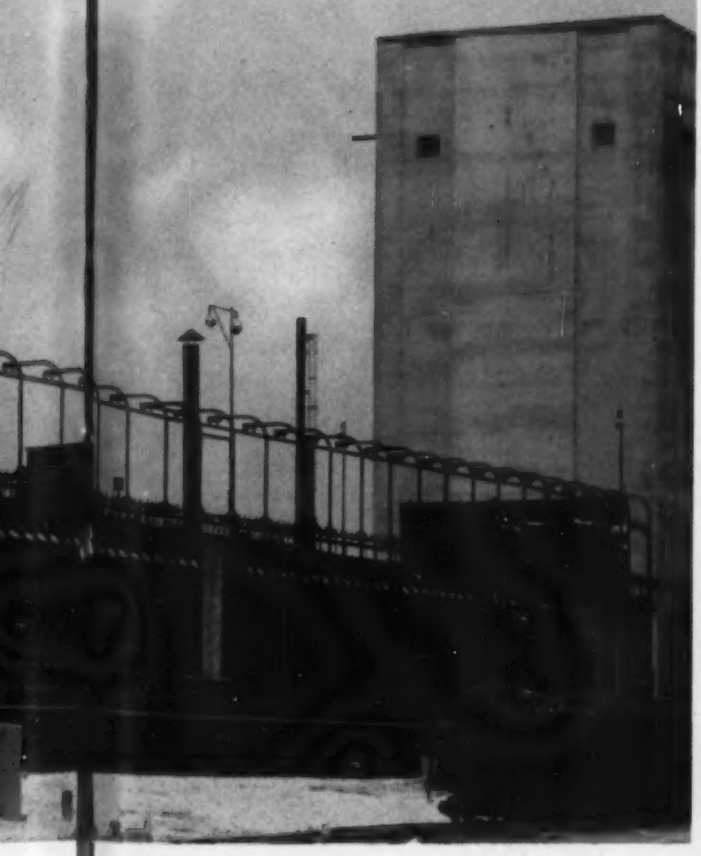
In cooperation with several of the largest users of hot metal cranes Dravo has made exhaustive tests of crane cab air conditioning. When you buy DRAVO CRANE CAB COOLERS you will find these outstanding advantages, developed through research with successful operating installations:

- **Air-cooled condensers which completely eliminate water connections.**
- **Self-contained unit which requires electrical connections only.**
- **Forced ventilation of motor and control cabinet with cool filtered air.**
- **Mill-type construction of equipment, readily accessible for servicing.**

DRAVO CORPORATION

PITTSBURGH • PHILADELPHIA CLEVELAND • NEW YORK • DETROIT WASHINGTON ATLANTA • WILMINGTON

6 Reasons why Your Coke Oven Plant should be built by Koppers



Koppers-Becker Low-Differential Coke Ovens with Waste-Gas Recirculation are the most advanced ovens available and they have these advantages:

1. They make the best possible grades of domestic and metallurgical coke from suitable coals under widely-varying conditions with the least underfiring requirements, and the highest yields of byproducts.

2. They can be built (without interference with the uniformity of heating) in oven capacities up to 20 net tons of coal per oven charge, in small or large batteries, to suit local conditions.

3. They can be underfired efficiently with coke-oven gas, natural gas, blue gas, carburetted water-gas, propane, butane, high-B.t.u. refinery gas, producer gas or blast-furnace gas, producing uniformly heated coke over a wide range of coking times.

4. They are built of the best materials available and of sturdiest design; are free from complications; are simple to control, and accessible throughout, insuring low maintenance cost and long life.

5. They can be operated at high speed with greater safety and at lower flue-temperatures because of the action of the waste-gas recirculation system.

6. By means of a separate and efficient blast-furnace-gas-enriching system, they can be operated to produce as much coke when underfired with low-B.t.u. blast-furnace gas as when underfired with coke-oven gas with the least requirement of high-B.t.u. coke-oven gas for enriching.

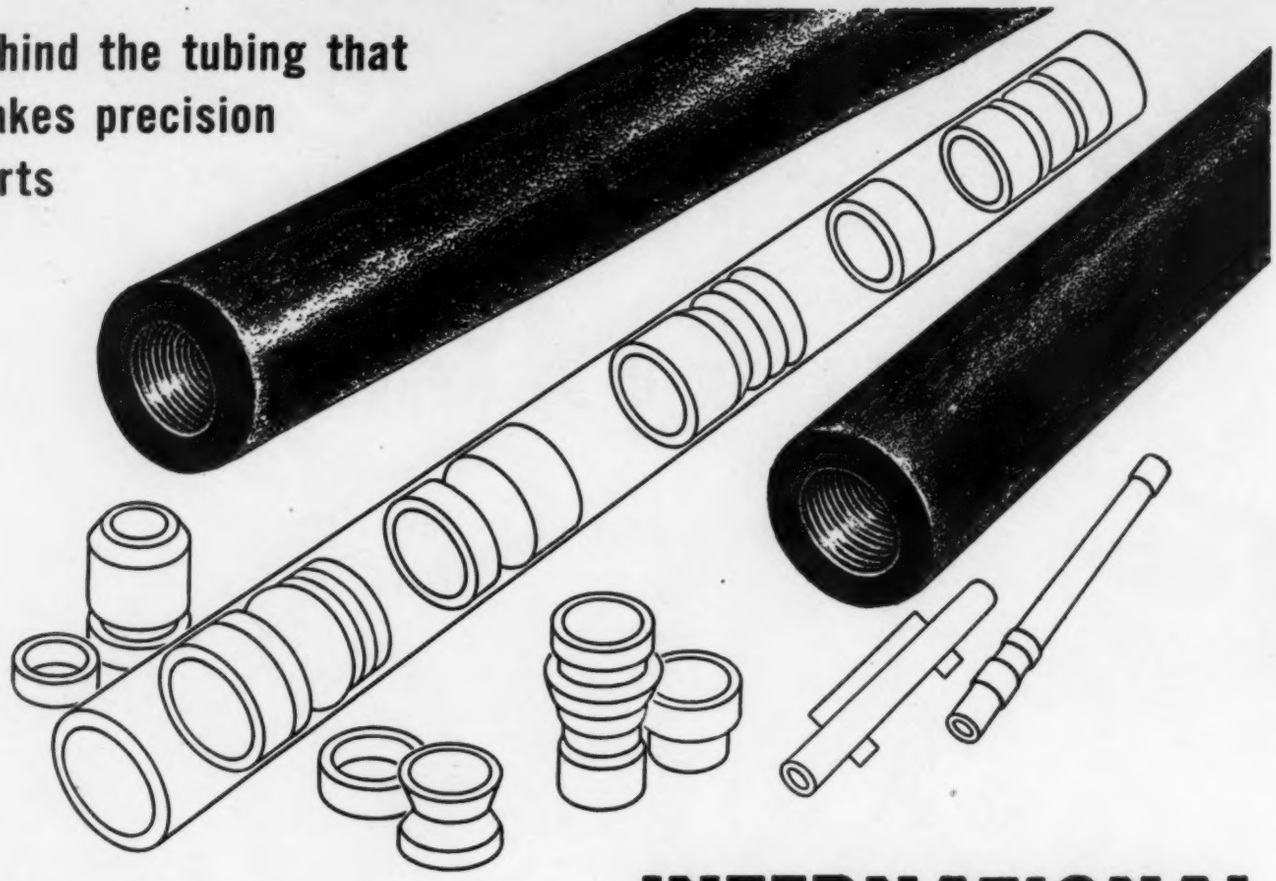
Koppers engineers will be glad to work with you on your plans for coke oven plants, light oil plants, by-product plants, gas-purification systems, gas producers, precipitators and any other equipment or apparatus connected with coal carbonization.

K
KOPPERS

KOPPERS COMPANY, INC.

KOPPERS BUILDING, PITTSBURGH, PA.

behind the tubing that makes precision parts



INTERNATIONAL GRAPHITE ELECTRODES

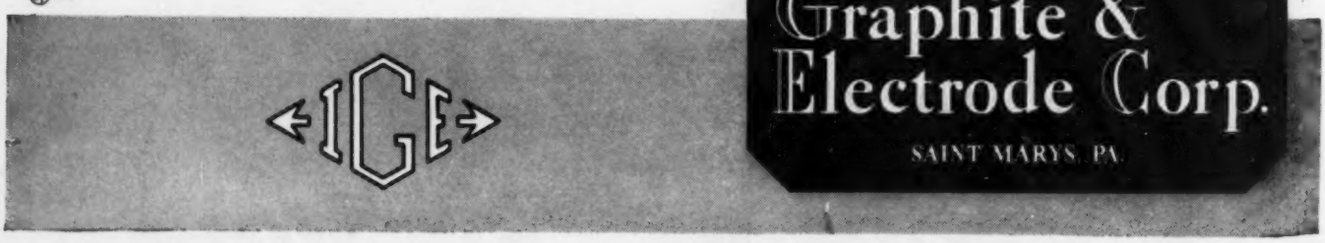
Makers of quality steel tubing know the importance of close production control. In the manufacture of mechanical tubing for precision parts, perfection in every production detail is imperative. For years, leading tube makers have been depending on International Graphite Electrodes as an important factor to electric steel quality. These manufacturers have proved to their satisfaction in the severest tests of all—in actual furnace operation under a wide range of requirements—that International Graphite Electrodes offer physical, electrical, and chemical properties in the combination they most desire.

Check over the qualities *you* want in electric furnace electrodes—the properties you'd see they had if you were *making* electrodes as well as *using* them. You'll find, too, that International Graphite Electrodes fully measure up to every exacting standard by which electrodes are judged.

For all around satisfaction and economical performance, specify International the next time you buy electrodes; find out first hand why they are so widely preferred by electric furnace operators. Write for details and prices today.

Specify INTERNATIONAL Electrodes for—Slow consumption—High current capacity—Low rate of oxidation—High thermal conductivity—High degree of purity—Consistently uniform properties and dimensions—Low cost per ton of production.

1591



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MAY, 1947

(1) Grinding Wheels

A grinding wheel manual explaining basic abrasives and all types of wheels is yours for the asking. The book includes a discussion of electro-high speed cut-off wheels. Even tool bit stock yields without a heating struggle to the keener, harder grits in true-running, amazingly strong, super-safe electro cut-off wheels. (645). Electro Refractories and Alloys Corporation.

(2) Drill Chuck Selector

Selecting exactly the right drill chuck for any straight shank drill is now made easy by means of a "slide-rule" type selector. With one simple setting of this selector, it is possible to determine instantly the catalog number of the style "B" drill chuck to be ordered. In addition, the selector shows recommended speeds and feeds for drilling various types of materials. Scully-Jones and Company.

(3) Industrial Strainers

A catalog has been published describing type K self-cleaning strainers which are recommended for service where a large amount of dirt or foreign matter is to be removed from water. Geared motor turns rotating element which blanks off straining element sections one at a time, allowing back flowing water to flush out dirt. (4 pages, A-12). Elliott Company.

(4) New Mill Motors

A folder introducing Westinghouse's new line of standardized mill motors, series 600, type MC, 7½ to 200 hp, series, shunt, compound wound, 230 and 550 volts, is available. The new standardized mill motors have cast steel frames especially designed to meet severe operating conditions encountered in heavy duty applications. The folder describes how the heavy duty mill motors meet the AISE standards. They are designed to give dependable performance for a variety of heavy duty applications including steel mill auxiliary drives, cranes, hoists, electric shovels and drag lines, coal and ore bridges, mine hoists, railway turntables, lift bridges, traffic bridges, conveyors, etc. (DB3800-9). Westinghouse Electric Corporation.

(5) Electric Magnets

A catalog containing eight pages on lifting magnets with detailed information on construction features of magnets and magnet controllers, as well as sizes, capacities and applications for all models is available. (112) Ohio Electric Manufacturing Company.

(6) Plant Cooling

Ilg Electric Ventilating Company pioneered the idea of drawing cool, refreshing nighttime air through the home for comfort during heat waves. In succeeding years, the idea was adapted to stores, offices and other commercial applications with great success. At the time World War II opened, steps had been taken toward introducing this idea into industrial establishments. Highlights of the story are given in a folder which you may want. (1404W). Ilg Electric Ventilating Company.

(7) Silicone Products

Silicone products are described in the third edition of a catalog on "Dow Corning Silicones, New Engineering Materials." We believe you will be keenly interested in this silicone catalog listing all of the silicone products now available, and containing many charts and graphs, descriptive of the unusual properties of this rapidly increasing family of organo-silicon-oxide polymers. Dow Corning Corporation.

(8) Blast Coils

A new catalog describing "Grid" blast coils has just been published. It contains a detailed description of the one piece high test cast iron construction of the "fin" heating sections, the exclusive feature of blast coils. Diagrams of installations, performance charts, temperature differential conversion tables, physical data, and specifications are included in this catalog. D. J. Murray Manufacturing Company.

(9) Creep Stress Card

A new data card which shows, graphically, creep stress data for B & W Croloy 2¼ and approximate comparison of creep strength data for the various heat resistant B & W Croloy steels is available. This card is for general or comparative purposes only, and is not designed for use where precise figures are required. This card shows the superior creep strength at practically all the temperatures shown, a range of 900 to 1200 F, thus pointing up the particular value where high resistance to creep is the main factor involved. (104-A). Babcock and Wilcox Tube Company.

(10) Gas-Fired Furnaces

A new bulletin on crucible gas-fired furnaces, has been issued. This bulletin covers the complete Eclipse line of crucible furnace units, including the new "RB" and "SB" series. One page is devoted to technical data to men working on the melting of metals. Eclipse Fuel Engineering Company.

(11) Dump Trailers

Complete data on improvements in the design and construction of the "Phil-Dump" trailer truck, is available. The trailer is now completely equipped with pneumatic tires, and a center caster which is optional, for greater maneuverability, ease in handling, faster haulage and dumping of scrap, castings, and sand, in steel mills. Its construction includes the roll-over type body, chain release, and quick return to normal position. Of welded steel construction throughout the "Phil-Dump" trailer is of one cubic yard capacity. Phillips Mine and Mill Supply Company.

(12) Industrial Trucks

Four catalogs on electrical industrial trucks are yours for the asking. The catalogs are as follows: Three-Ton Low-Lift Truck, with an 11 inch platform height; Center-Control Fork Truck, 2000 and 3000 lb capacity; Locomotive type Crane Truck, 10,000 lb capacity; and the Electric Truck Catalog. These catalogs cover every type of electric truck needed for steel plant operation. Every steel mill man with a problem in the movement of materials should have these in his reference files. The electric truck catalog in particular contains complete technical data on capacities and construction features, with photographic views showing typical applications in plant operation. (52, 1612-C, 1306d, and 1115c). Baker Industrial Truck Division of the Baker-Raulang Company.

(13) Hydraulic Pallets

A new lightweight hydraulic hand pallet truck is described in an announcement folder. Illustrations show streamlined design resulting from use of light metals and new construction techniques. (221). Lyon-Raymond Corporation.

(14) Blast Furnace Stoves

A 6-page bulletin containing new and complete information on the Bailey blast furnace stove has been published. The Bailey blast furnace stove described is designed to provide shell and dome construction which allows the best possible method of installing insulation and brick work, taking into consideration varying temperatures in the different zones of the stove, and also to provide the greatest possible stability in the brickwork comprising the combustion and checker chambers. The new bulletin contains complete design data, drawings, and specifications of the cross-circulation checker, describes in detail the improved shell wall construction, and the fabricated steel stove bottom. William M. Bailey Company.

(15) Sodium Hydride Descaling

A booklet is available telling how to remove scale from machined, forged, or cast of any metal or alloy which does not react with molten caustic and whose physical characteristics are not adversely affected at 700 F. The new efficient method is the Du Pont sodium hydride descaling process, that positively removes all scale quickly with no pitting, or pickling losses. It makes timing in the bath a simple matter, that can mean to you, in brief, important savings in time and money. The booklet also gives the many advantages of the process, and shows how they help you, tells exactly what sodium hydride descaling is, how it works and where it is used, along with interesting photographs, diagrams, and technical information, designed to help you get the most out of your scale removal jobs. Electrochemicals Department, E. I. du Pont de Nemours and Company.

(16) Heat Exchangers

Publication of a new bulletin, Catalogue Section M8808, describing standard, seven tube heat exchangers of "Karbate" impervious graphite for use under highly corrosive conditions has been announced. The exchangers described are available in three sizes of 4 ft 3 in., 7 ft 3 in. and 10 ft 3 in. length with effective outside tube areas of 8.2 sq ft, 16.4 sq ft and 24.6 sq ft respectively. All these "Karbate" exchangers have the well-known properties of high thermal conductivity and resistance to the action of most acids, alkalis, and other corrosive chemicals. National Carbon Company, Inc.

(17) Selenium Rectifiers

A new loose leaf catalog on selenium rectifiers is available. The catalog covers the scope of uses of selenium rectifiers in the plating fields and in general industry, explains their operations and advantages and includes a questionnaire, which when filled out, will bring information on rectification problems. Richardson Allen Corporation.

(18) Precipitators

A new 19-page illustrated booklet is obtainable covering "Roto-Clone" dynamic precipitators, devices particularly adapted to the dry collection of practically every type of granular industrial dust. Among the many illustrations are detailed views of wear liners, radiation shields, skimmer precleaners, aftercleaners, rotary locks, trickle valves and self-contained units together with capacity and dimension table for each size. (Type D). American Air Filter Company.

(19) Chain Digest

A copy of the Union Chain Digest is yours for the asking. The catalog covers drive and conveying chains and sprockets; finished steel roller chains and sprockets; silent chains and sprockets; and flexible couplings. The digest is the condensed listing from separate catalogs on the foregoing titles, which are available if the information given in the digest is not complete enough for your purposes. (Digest D-1). Union Chain and Manufacturing Company.

(20) Electronic Products

The publication of a new 164-page catalog, covering radio and electronic products has been announced. Special emphasis is placed on equipment for industrial maintenance, research and production requirements. Over 10,000 items are included, with detailedlistings of electronic tubes, test instruments, transformers, resistors, condensers, rheostats, relays, switches, rectifiers, tools, wire and cable, batteries, sockets, generators, power supplies, and other types of equipment in this field. (1947). Allied Radio Corporation.

(21) Refractory Cement

A new air setting refractory cement, called Armstrong's air set, that combines all the essential engineering requirements with the maximum of practical workability required by the brick mason is described in a bulletin just issued. The new cold setting cement is designed for use as a bonding mortar with fire brick and insulating fire brick. It is also recommended as a protective facing for fire brick or insulating fire brick furnace linings. The cement reduces maintenance costs because it provides a tight, permanent joint and strong bond that does not allow brick to become loose in the wall and protects the furnace lining. (11-26-247). Armstrong Cork Company.

(22) Safety Switches

For use in outdoor applications and other locations where adverse atmospheric conditions prevail, an improved line of weather-proof safety switches is announced. A bulletin is available telling how these switches are exceptionally compact and are of raintight and dust-tight construction. Enclosures are heavy gauge steel with aluminum finish and have slanted roof with driptrough over the front door. A heavy sponge rubber gasket makes a tight seal between the box and the door. (1300). Electric Controller and Manufacturing Company.

(23) Permanent Magnets

An unusually complete bulletin on the "Use, Design and Fabrication of Permanent Magnets" is being offered to electrical departments of the steel industry. The bulletin contains an apt discussion of the advantages and limitations of permanent magnets in many present and potential applications — plus technical information and data on all known magnet materials and basic design formulae. The bulletin is primarily a magnet engineering treatise and was prepared by engineers. Thomas and Skinner Steel Products Company.

(24) Wire Rope Lubricant

Leadolene "Klingfast" wire rope lubricant is covered in a new bulletin available to you. Of special interest to wire rope manufacturers is the fact that Leadolene "Klingfast" is available in colors which will serve to identify as well as protect their products. The new lubricant possesses the indestructible ph-ilm which is characteristic of Leadolene lubricants. The catalog claims the following properties: unusual resistance to abrasion and corrosion, even where salt or acidic vapors are present; a high affinity for steel and other metals, which develops maximum adhesion, prevents drippage, and yet maintains permanent flexibility; a high resistance to water, lubricating oils and greases, scale, dusts, and other prevalent forms of contamination; excellent resistance to deterioration or malfunction caused by temperature extremes. Brooks Oil Company.

(25) Counting Devices

A new catalog on counting devices for industry is available to you. For your greater convenience in quickly finding and correctly ordering the best and most economical counting device for your job, the book has been rearranged by dividing counters into two definite categories: (1) counters which are production items; (2) counters which are not production items (non-standard counters). Every effort has been made to include on each page all the necessary mechanical information pertaining to the counter shown on that page. Following each group of similar counters, there appears an exterior dimensional drawing, giving mounting dimensions, shaft projections, etc. All necessary visual guidance in ordering has been provided, on each page, regardless of seeming repetition to save you from referring from one page to another, and back and forth. All production men who have a counting

problem should have this catalog in their reference files. (G47). Veeder-Root, Inc.

(26) Materials Handling

The part played by fork lift trucks in the materials handling job at Ball Brothers Company, Muncie, Indiana, is the subject of a new, illustrated lift truck job study just published. Ball Brothers Company, manufacturers of glass jars and bottles, seals and caps, has recently modernized its handling system to accommodate the huge task of moving materials to and through production that has a volume equivalent to 50 box cars and 20 trailer trucks each day. (Survey). Towmotor Corporation.

(27) Texrope Drives

A new 144-page, indexed catalog for "pre-engineered" stock Texrope drives which simplifies drive selection so persons untrained in V-belt engineering can readily specify proper drives, has been announced. In the process of development by Texrope engineers for more than a year, the catalog is said to represent one of the most outstanding compilations of engineering data ever assembled for the V-belt industry.

Nearly two-thirds of the new book is devoted exclusively to pre-engineered stock Texrope drives for all applications from one to 150 horsepower. More than 22,000 stock drives are listed in this section. Drives for all horsepowers, motor speeds, ratios and driven speeds have been accurately pre-engineered and are systematically listed on die-cut pages, indexed according to horsepowers. (761). Allis-Chalmers Manufacturing Company.

(28) Portable Brakes

A data sheet has been published on Webco portable brakes in capacities up to 49 in. which give you quick, accurate bends on the job . . . . operate on a production basis in your shop. The sheet gives specifications and prices of the brake that sheet metal men have been looking for. The brake is portable and compact fitting easily into the back of a car or pick-up truck. Webb Machine and Tool Company.

(29) Machine Tool Motors

The advantages of totally-enclosed motors, of both the fan-cooled and the non-ventilated type for application to machine tools, are described and illustrated in a new eight-page bulletin. (MU-25A). Wagner Electric Corporation.

(30) Lighting Units

Methods of utilizing the new Holoflux lighting unit is pictured and described in a newly published folder. The folder tells about the true efficiency of a lighting unit consisting of a number of factors which, put together, mean ease of seeing and comfort in living. In this case, the new curved-type Controlens sends a strong, intensive, pattern of light downward to insure a high level of illumination, with a noticeable absence of glare. (FB 47). Holophane Company, Inc.

(31) Selenium Rectifiers

A booklet just published gives electrical data and prices on a complete line of standard selenium rectifier equipments. Whatever your d-c needs, you'll find a rectifier designed for that job among these rectifiers. Subjects covered in the 12-page booklet are: electroplating equipment; industrial truck battery chargers; industrial power supplies; general purpose battery chargers; cathodic protection equipments; power supplies; central station battery chargers; and telephone battery chargers. (E713). Federal Telephone and Radio Corporation.

(32) Metal Cleaning

"Deoxidine" is the title of a new technical service data sheet which describes how you can be helped to do a better rust-removing and metal cleaning job, thus conditioning metals correctly for painting. The sheet tells also of the number of grades of Deoxidine, each one designed for a particular metal cleaning job, and gives general information which will indicate the type or types best suited to your own metal cleaning requirements. (TSDS 3-1-1-2, April 47). American Chemical Paint Company.

(33) Rubbing Brick

A new bulletin describes a new "Handy-Handle" finishing brick, for tailor-making any shape of fire brick. This device is especially designed and curved for a comfortable grip with either hand. Its selected sharp grains are reported to make it easy to use. It is recommended by the manufacturer for removing form marks from concrete surfaces, leveling insulating brick, or rounding edges for special installations. This especially finished "Fluted-Face" finishing brick is claimed to aid in expediting production on all types of masonry jobs. (73). Clipper Manufacturing Company.

(34) Steel Shears

A catalog is available with specific data on slitter knives, spacers, and straight blades. The blades described are made of special steel with uniform hardness and are accurately ground. Other information on solid steel shear blades and gang slitters is included. Ohio Knife Company.

(35) Masonry Construction

"Corrosion-Proof Masonry Construction" is the title of a 56-page booklet that is filled with helpful information to save you time, money and worry. The booklet describes a better corrosion-resistant floor for metal finishers using alkaline cleaners. Metal finishers using acid pickle and plating solutions know that the average "acid-proof" floors don't last too long when called upon to handle acids and alkalies alternately. The floor described in the above booklet will resist strong and weak alkalies, strong and weak acids, oils, solvents or water, and cold water or live steam. U. S. Stoneware.

(36) Speedomax Pyrometers

A 16-page catalog giving detailed information about Speedomax Type G Pyrometers. Fully illustrated are the features of Speedomax's highly responsive balancing system, the result of over a dozen years' experience with high-speed industrial recorders. (ND46-1). Leeds and Northrup Company.

(37) Centralized Lubrication

A bulletin is available describing the Farval centralized lubricating system. The described system delivers oil or grease under pressure to a group of bearings from one central station, in exact quantities, at regular intervals. Farval is the Dualine system with the positive piston displacement valve. This valve has but two moving parts and is fully adjustable, with a tell-tale indicator at each bearing to show the job is done. (25). Farval Corporation.

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(38) Cable Splicing

A booklet with samples is available showing how the Okonite splicing compound, in a typical test, was securely bonded to the connector and conductors and had become vulcanized into a firm, homogeneous seal that not one drop of water had penetrated. This is why so many users say that for long, trouble-free service there is nothing like Okonite rubber and Manson friction tape for splicing rubber-insulated cables. (1007 and samples). Okonite Company.

(39) Electric Products

Three excellently prepared bulletins are obtainable for your electrical files covering: 1 — Diverter-pole motor generators for main stations and substations, either attended or unattended. 2 — Electrolytic motor generators for any electrolytic process; battery-charging motor generators for any motive power application; diverter-pole motor generators for floating charge of standby batteries; frequency changers; industrial dynamometers; special motors and generators; and synchronous motors and generators. 3 — New single-circuit battery charger. The booklets are complete with details, sketches, and typical applications. (207, 208, and 210) Electric Products Company.

(40) Instruments

A new bulletin listing over 150 different items maintained in stock for immediate delivery has been published by Bristol, manufacturers of recording and controlling instruments for industrial processes. The new bulletin lists recording thermometers, pressure gauges, voltmeters, ammeters, and pH recorders. Also listed are recording controllers, indicating controllers, miscellaneous instruments and accessories. (W1811). Bristol Company.

(41) Coated Abrasives

A series of booklets on coated abrasives are made available to you by a firm that has been making a study of wartime applications to peacetime industry. The series consist of "Coated abrasives"; "Coolants for abrasive belts"; "Belt sanding of metal"; "Testing coated abrasives"; "The polishing lathe"; "The effect of moisture on the work value of glue-bonded coated abrasives";"Abrasive disc sanders". Clover Manufacturing Company.

(42) Bleeding Ingots

A booklet is obtainable giving you valuable information about an exceptional process of "flushing"-bubbling a dry inert gas through metal just before casting, which is the most effective method of eliminating "wild heats" or "bleeding ingots." The booklet shows how this process can be applied to both ferrous and non-ferrous metals. (ADR35). Air Reduction Sales Company.

(43) Silica Brick

A booklet is yours describing "Vega," the super-duty silica brick which is 60 to 100 F higher in refractoriness under load than commercial silica brick of the usual quality. The booklet shows how Vega has given as much as 20 to 30 per cent longer life in open hearth roofs, permitting higher operating temperatures and increasing the tonnage output; it is a complete technical story on the background of development and experience on this new brick. Harbison-Walker Refractories Company.

(44) Smokeless Oil Burners

A catalog is available describing an entire line of smokeless oil burners for industry. The booklet tells how these burners produce clean efficient combustion, are simple to control and temperature may be maintained or varied with utmost ease. The burners, according to the book, soon pay for themselves in the saving of time and fuel, greater production and a clean shop. Smokeless Oil Burner Company.

(45) Diesel Locomotives

A complete set of bulletins prepared in a portfolio describing Whitcomb diesel-mechanical and diesel-electric locomotives is available. The locomotives are designed for industrial and railway service. Bulletins cover 3, 6, 10, 16, 25, 35, 44, 50, 65 and 80 ton locomotives. Whitcomb Locomotive Company.

(46) Cooling Fans

With the advent of summer, now is the time to think of man cooling fans. Specifications and technical data are available to you covering a complete series of steel mill fans of all types. Included are construction details with photographs and drawings of the fans. Truflo Fan Company.

(47) Electric Hoists

A newly-published 8-page bulletin completely describes a new line of Whiting electric chain hoists. This bulletin analyzes the need for hoists, shows how in 12 minutes per day operation the Whiting hoist will pay for itself, describes the operation and gives complete specifications, speeds, and prices for ¼, ½, and 1 ton hoists. (H-100-A). Whiting Corporation.

(48) Gradiation

"Speed Heating of Metals by the Gradiation Process" is the title of a booklet on improved heat processing of metals. The booklet offers a review of gradiation (the name gradiation implies radiation, high speed, high temperature, solar-like heat, and gradient) in the metals industry. It is a summary of principles and specific performances. One of the commonest of industrial fuels, commercial gas, is caused to give results of a new order in speed and quality. Selas Corporation of America.

(49) Oakite

Two informative, illustrated booklets are available providing many specific production suggestions for improved machining, cutting, grinding and related operations on ferrous and non-ferrous metals and for preventing formation of rust on ferrous surfaces between machining operations. The first of these booklets discusses fully the applications of Oakite soluble oil and addition agents for meeting unusual or special machining problems on a wide range of work, gives starting point formulas for mrking up coolant emulsions for operations on steel. The second booklet provides valuable data on temporary or semi-permanent rust protection of ferrous parts or work with special protective oil, following such operations as grinding, machining, pickling, tumbling, sand blasting and brazing. (5239R and 6322R). Oakite Products, Inc.

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If You're in Hot Water

Over Hot Circuits

SWITCH TO ROCKBESTOS A.V.C.

When you're on the carpet because of repeated wire failures that skyrocket maintenance expense—you need ROCKBESTOS A.V.C.

Here's why: Rockbestos wires and cables are *permanently* insulated with impregnated asbestos that resists extreme heat and corrosive fumes. They won't bake brittle, crack or flow—even at torture temperatures up to 230° F. They won't burn or support flame. They withstand repeated exposure to oil and grease without rotting. They also resist aging and oxidation because asbestos doesn't deteriorate.

One or more of 125 standard Rockbestos constructions in 300 to 5000 volt ratings can do a real cost-saving, high-performance job for you—single and multi-conductor power cables, switchboard and lighting wires, control cables and other N. E. code types. Write for catalog, recommendations or samples.

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188 Nicoll St., New Haven 4, Conn.

ROCKBESTOS A.V.C.

The Wire with Permanent Insulation

QUICK Facts About LONGER Cable Service

Type AVA, Rockbestos A.V.C. 600 Volt Power Cable illustrated (No. 18 AWG to 2,000 MCM) and similarly insulated Motor Lead Cable have a maximum operating temperature of 230° F., and this failure-preventing construction:

Age-resistant impregnated asbestos braid that resists heat, flame, moisture, oil, grease and corrosive fumes.

Outer wall of felted asbestos insulation, impregnated with heat, flame and moisture resisting compounds, won't dry out, crack, flow, rot or burn.

Asbestos-protected varnished cambric for high dielectric strength and added moisture resistance.

Inner wall of impregnated felted asbestos withstands conductor-heating overloads — won't break brittle or burn and helps provide greater current carrying capacity.

Conductor is perfectly and permanently centered in helically applied non-flowing insulation.

One of 125 different constructions designed by Rockbestos for severe or unusual operating conditions.

NEW YORK BUFFALO CLEVELAND DETROIT CHICAGO ST. LOUIS LOS ANGELES PITTSBURGH SAN FRANCISCO SEATTLE PORTLAND, ORE.

(*Continued from page 98*)

simple that untrained personnel can obtain reliable results.

The detector consists of a small glass tube sealed at both ends and a rubber bulb all packed into a small kit that fits into the pocket. When the presence of monoxide is suspected the kit can be opened, the tip broken off a small tube and one end inserted in the bulb to draw air samples through the chemicals in the tube.

If carbon monoxide is present the yellow chemicals will turn green in thirty seconds. The darker the shade of green, the higher the monoxide concentration. A matching color chart tells how high the concentration is.

This new gadget can be used extensively wherever carbon monoxide fumes might be expected. The United States Safety Service Company, has been licensed by the government to manufacture the gels and instrument and will be in production on the item within the next few months.

THE ENGINEERING MART
An IRON AND STEEL ENGINEER service to steel mill operators
See page 000 this issue.

KAISER STEEL SETS 4 PRODUCTION RECORDS

▲ Four new production records were established by Kaiser Steel at its Fontana, California, plant during March, including an all-time high of 64,454 tons of steel ingots, it was reported by A. B. Ordway, vice president and general manager. The best previous ingot output at Fontana was 64,271 tons in January.

Over-all production has been rising steadily even since the war years, when the Kaiser plant was straining to produce steel for ships and shell cases. The best wartime ingot production was 61,979 tons in March, 1945, showing that the mill has increased its output by 2,657 tons per month in just two years.

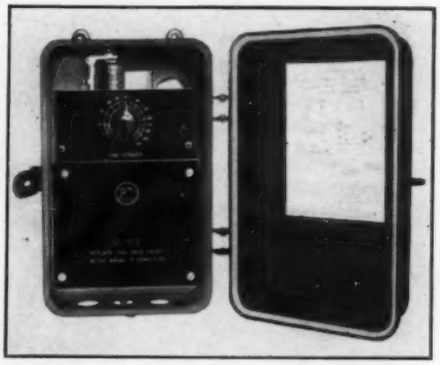
New records were registered in March also in the merchant and structural mills, Mr. Ordway said. Merchant mill tonnage was 16,060 as against the previous high of 15,307 in February. The manufacture of structural products climbed to 28,075 tons as compared to the best previous mark of 24,007 tons in January.

The company's own iron ore mine at Vulcan set a production record of its own in March when it mined 93,228 tons for the Fontana blast furnace. The best previous output was 77,114 tons in June, 1944.

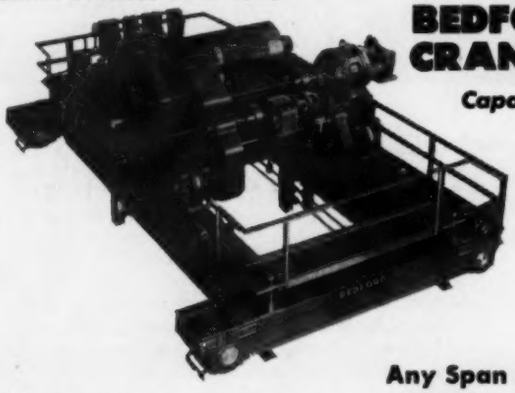
ELECTRONIC TIMER SETS WELDING INTERVALS

▲ Photoswitch electronic welding timer is designed for interval timing of welding operations over a range of 3 to 120 cycles. It is recommended for all general-purpose spot welders and

Application to steel mill rolling is in the realm of possibility.



CRANE BUILDERS Since 1903



BEDFORD CRANES
Capacities 5 to 150 Tons

Designed and Engineered to Meet Your Requirements

Any Span or Lift
Send For Your Copy Of Catalog

ELECTRIC OVERHEAD TRAVELING CRANES
GANTRY CRANES • STEEL DERRICKS
BUILT TO YOUR SPECIFICATIONS
STRUCTURAL STEEL • STEEL BUILDINGS

BEDFORD FOUNDRY & MACHINE CO.
Engineers Designers Fabricators
BEDFORD, INDIANA U. S. A.
Gray Iron Castings

"Circular STARE-FACE"

● When Falcon's photographer was asked to get a shot of a 1600-pound resistance welding electrode ring (upper right), he put the three ten-pound electrode rings with it to show relative size.

When the photo was turned upside down (upper left), it was dubbed by an innocent bystander, "Circular Stare-Face."

Select your own title.

Remember these facts about Falcon Beryllium Copper Heat Treated Electrodes—they are furnished rough-turned to insure receipt of sound castings—available in any hardness up to 120 Rockwell B or 250 Brinell—highly resistant to abrasion or wear—will require minimum dressing or trimming—dense—and of high electrical conductivity — they insure maximum serviceability.

Furthermore, they are delivered promptly, with or without hubs, in weights from 10 to 1800 pounds.

TELEPHONE COLLECT — 94355
FALCON BRONZE CO.
YOUNGSTOWN 3 OHIO

fulfills the specifications of NEMA Class 1A timers. It is applicable to manual, air or motor operated welding equipment requiring either beat or non-beat operation.

The timer incorporates many features of particular importance to the welding field. The timing adjustment can be set for any interval from 3 to 120 cycles. It is calibrated at these two settings, and its accuracy throughout the range is within 2 per cent. The timing adjustment is located on the panel inside the housing, thus providing a tamper-proof setting. The timer may be used with either a 115 or 230 volt a-c supply. By simple selection of terminals on the terminal panel, the timer will provide beat or non-beat timing (initiation of timing cycle from momentary contact or sustained contact). The terminal panel is provided with a dead front so that there is no possibility of the operator touching the terminals when setting the timing interval.

Combinations of this timer are used when it is desired to control also other portions of the welding cycle, such as the squeeze, heat, cool, on and off periods.

SCOVILL AWARDS CONTRACT TO TURNER CONSTRUCTION

▲ A contract totalling approximately $2,000,000 covering building work in connection with an addition to the rolling mill of the Scovill Manufacturing Company, Waterbury, Connecticut, for which Stone and Webster Engineering Corporation are project managers, has been awarded to the Turner Construction Company. This addition represents a major portion of its modernization program and will give better production to present facilities.

The contract covers an addition to an existing building completed in 1916. The addition, which will be used for the housing of heavy modern equipment for cold rolling copper alloys in sheet and strip form, will be one story high and 1250 feet long by about 80 feet wide. It will have a modern roof design to match the present building, permitting maximum light and ventilation. Construction will be of the brick, steel and concrete mill type.

Approximately 180,000 square feet will be contained in the addition. Over-all height will be 30 feet, allowing a clear working height under the traveling cranes of approximately 21 feet.

CONTINUOUS CONTROL IN NEW BROWN DEVELOPMENT

▲ Electronic principles of continuous control have been developed for the first time in the industrial thermometer and pressure gauge field.

The development will provide an instrument which will assure high quality, speedy production and fewer rejects in industries which rely upon thermometers and pressure gauges for manufacturing and processing. Some processes heretofore controllable only with electronic potentiometers can now employ the new instrument to obtain wanted results.

The instrument, made by the Brown Instrument division of Minneapolis-Honeywell Regulator Company, will be known as the "Electr-O-

Before You Buy ANY Domestic Water System
See the PEERLESS Water King Advantages!

Exclusive Water King Features
SIMPLIFY WATER PUMPING—LOWER COSTS

The Most Advanced Pumping Principle in the Last 10 Years

"Magic Wings to Water Lift"

The trouble-free simplicity of the patented Peerless Water King is a real innovation in water pumping. Here is the ideal pump for domestic and light industrial water systems, meeting every requirement for simplified pumping at lower costs.

The Peerless Water King is the pump with "Magic Wings to Water Lift." The Water King is a shallow well pump, embodying an exclusive "magic" pumping element: a hard chrome rotor revolving in a rubber stator that draws water upward and forces it into pressure tank—the most advanced pumping principle in the past 10 years. Capacities: 275 to 860 g.p.h., against pressures up to 40 lbs. *There are no parts of the pump underground.* 100% automatic. Easily installed over the well or offset. Pumping element highly resistant to abrasive and corrosive action. Finely engineered—Compact—Quiet—Trouble-free.

PLAN WITH PEERLESS
Peerless has a pump for all your needs for water—from 10 to 220,000 gallons per minute! Write to Peerless factory or district office for literature and name of nearest dealer. *Descriptive Bulletins available.*

PEERLESS PUMP

THE PEERLESS WATER KING

Covered by Peerless Patent 2,346,428 Mfd. under R. Moineau's U. S. Letters Patents 1,892,217-2,-068,407—Reissue 21,374 and Canadian Patent 352,574; Robbins & Myers, Inc., Sole U. S. and Canadian Licensee.

2 PEERLESS DOMESTIC WATER SYSTEMS

A PEERLESS JET SYSTEM, TOO

For Deep or Shallow Wells. Capacities: 120 to 7500 g.p.h. Lifts up to 120 feet.

This amazingly simple and compact Peerless Jet Water System produces all the water you want for normal light industrial operating requirements. It is a pressure system, entirely automatic, and occupies little more space than an electric motor. A Peerless Jet Water System offers a lifetime of trouble-free water service at minimum cost. Can be installed over well or offset.

Write for Bulletin B-155-1 describing Jet Water System in detail.

PEERLESS PUMP DIVISION
FOOD MACHINERY CORPORATION
Factories: Canton 6, Ohio Quincy, Illinois Los Angeles 31, California
District Offices: Canton 2, Ohio, Ardmore, Pa.; Decatur, Ga.; Dallas 1, Texas

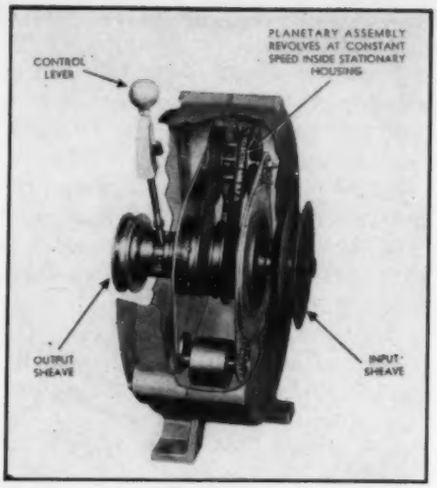
Vane". It is applicable, it was said, in hundreds of processes which demand accurate control of temperature ranging from 100 degrees below zero to 1000 degrees above.

The control unit operates on the principle that when a metal vane is interposed between two oscillator coils, the state of oscillation can be made to change or stop in an electronic circuit. This change or stopping oscillation causes the electronic circuit to operate a load relay.

SPEED SELECTOR PROVIDES SPEED FROM 0 TO 800 RPM

▲ A new improved variable-V-planetary infinite ratio speed selector, designed as an independently mounted transmission is jointly announced by Speed Selector, Inc., Cleveland, Ohio, and B. F.Goodrich Company, Akron, Ohio.

The speed selector employs planetary motion with four variable pitch sheaves and two standard cross section V-belts to provide any speed from zero to 800 rpm at constant torque, from a constant speed power source. The multiplying action of the planetary converts a slight change in sheave pitch diameter to a wide change in output speed. The high and nearly constant belt speeds permit almost instantaneous changes in output speed by the convenient lever action self-locking control handle.

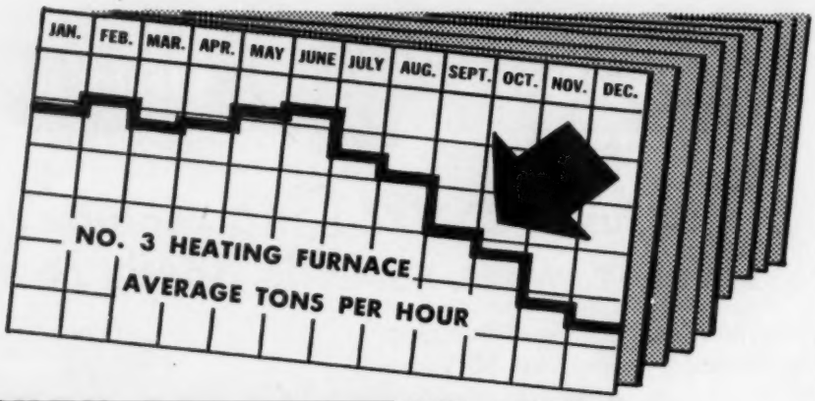


The multiplying action of the planetary converts a slight change in sheave pitch diameter to a wide change in output speed.

The new speed selector models, available in ½, 1 and 2 horsepower output, are simple and sturdy in construction. Cast iron sheaves on hardened and ground shafts and guide pins with sealed prelubricated ball bearings are mounted in sturdy cast aluminum housings. Optional V-belt or flexible coupling input and output make the speed selector easily adaptable for mounting in any position on new or existing equipment.

COMBUSTION CONTROL HAS ELECTRONIC FLAME GUARD

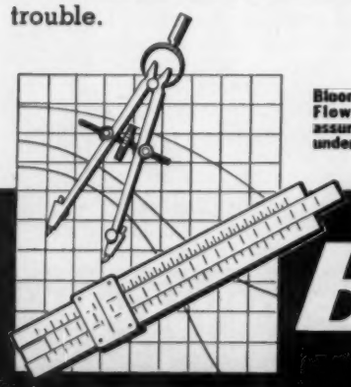
▲ To protect against the hazard of explosion caused by flame failure in industrial oil burner installations, Combustion Control Corporation announces a new "Fireye" photoelectric flame failure safeguard. The instant flame fails, fumes and gases accumulate and combine with air to form a dangerous, highly explosive mixture within the combustion chamber. When this condition occurs, control time is vital. The flame failure safeguard provides for complete pro-



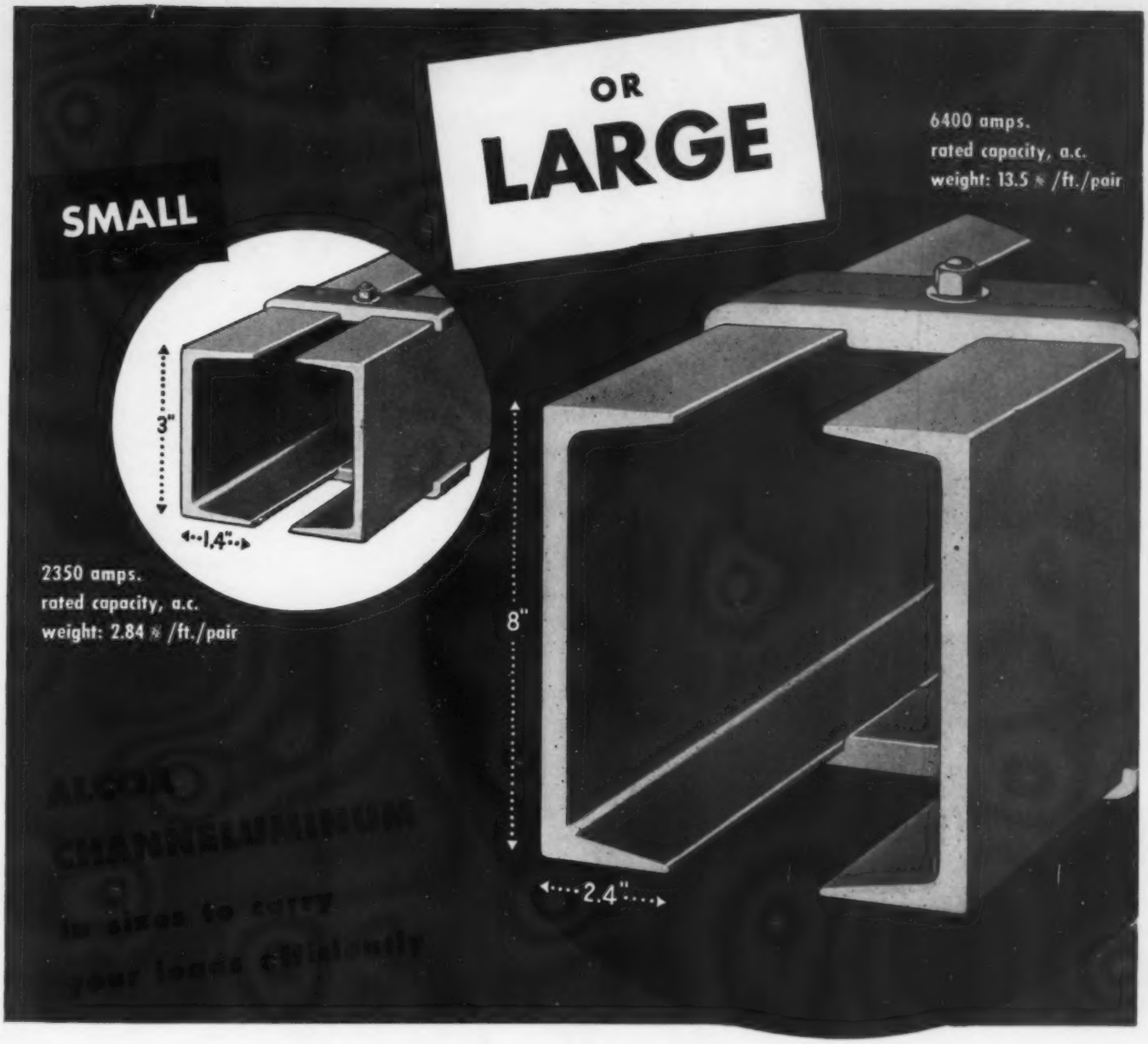
WHEN PRODUCTION LAGS···
SEE BLOOM ENGINEERING

When furnace output needs "pepping-up"—when fuel costs rise—let Bloom Engineering investigate the cause of your trouble. Extensive experience with heating furnaces of all types enables our engineers to analyze conditions and suggest a remedy. Perhaps a relocation of burners is needed; perhaps a more uniform flow of fuel—the solution may be simple or difficult. Whatever it is, you can use our knowledge of furnaces and combustion to correct the conditions that are causing your trouble.

Bloom Constant Flow Oil Valve assures uniform fuel flow under varying pressures.



BLOOM ENGINEERING CO.
857 W. North Avenue Pittsburgh 12, Pa.



Aluminum has high electrical efficiency. And channels have high structural strength. Combine them, and you get Alcoa Channeluminum Bus Conductors that carry large alternating currents efficiently.

The dead-weight load on supporting structures is low. The channel cross-section gives good ventilation to reduce heat losses. And the flat surfaces of Channeluminum conductors permit rapid, easy erection without unusual hangers and supports.

Wherever large currents must be carried . . . in steel plants, plating shops, industrial plants of all types, it will pay you to specify "Bus Conductors of Alcoa Channeluminum."

ALUMINUM COMPANY OF AMERICA, 2128 Gulf Building, Pittsburgh 19, Pennsylvania. Sales offices in leading cities.

MORE people want MORE aluminum for MORE uses than ever

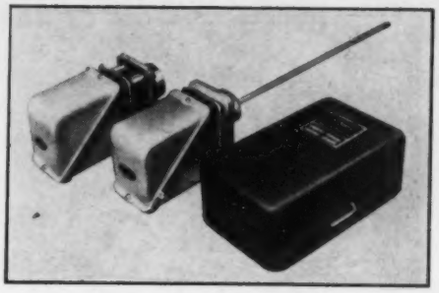
ALCOA ALUMINUM

IN EVERY COMMERCIAL FORM

tection against this danger. It photoelectrically "sees" that the flame has failed and instantly turns off the fuel supply and the burner.

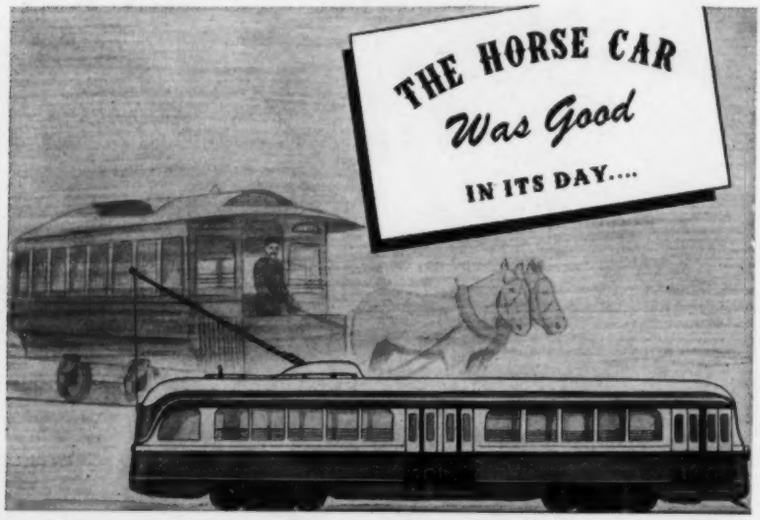
The equipment consists of a photoelectric scanner for monitoring the main oil burner flame and programming control for programming the oil pump, oil valve, and ignition system. Flame rod may be added to this combination if it is desired to monitor the gas pilot flame as well. The equipment is recommended for the control of all fully automatic oil burner installations.

The photoelectric scanner is exceedingly compact in design and readily installed on the burner plate either at the time of assembly of the original burner equipment or upon installation in the field. Since the scanner contains both the phototube and amplifier tube, no special shielded cable is required between the scanner and programming control. The photoelectric system is designed to withstand conditions of relatively high ambient temperature and is impervious to ambient humidity. It represents the last word in electronic design and embodies safe failure features hitherto unavailable.



The photoelectric scanner is compact and readily installed on the burner plate.

The programming control is designed to provide accurate setting of both oil valve delay and post ignition periods in seconds upon installation. Timing is accomplished through a synchronous motor. Relay contacts are of heavy duty type capable of handling directly a pump motor of 1 horsepower rating. The relay contacts are in an accessible location.



BUT...

It would only draw crowds of jeering spectators, if it appeared on the streets today. Science has progressed along every front, since the day of the horse-cars -- and so it is with pickling procedure.

CHEMICALS ACP PROCESSES

RUST PROOFING AND PAINT BONDING
Granodine *
Duridine *
Alodine *
Lithoform *
Thermoil-Granodine *

RUST REMOVING AND PREVENTING
Deoxidine *
Peroline *

PICKLING ACID INHIBITORS
Rodine *

Rodine* added to the bath, insures a well-controlled pickling cycle for both sulfuric and muriatic acids.

Rodine prevents acid attack on good metal; and it prolongs the life of the bath, through the prevention of acid waste.

With Rodine, over-pickling and acid embrittlement are held to a minimum.

Rodine holds down fumes -- makes pleasanter working conditions -- safeguards health and comfort.

For better control -- savings in metal and acid -- economical scale removal -- smoother surfaces -- improved pickling all around -- add Rodine to the pickling bath.

* Trade Mark Reg. U. S. Pat. Off.

AMERICAN CHEMICAL PAINT CO.
AMBLER ACP PENNA.

ELECTRIC METAL MAKERS TO MEET IN PITTSBURGH

▲ The fifteenth annual meeting of the Electric Metal Makers Guild, Inc., will be held at the Hotel Roosevelt, Pittsburgh, Pennsylvania, June 5, 6, and 7, 1947.

John E. Arthur, Crucible Steel Company of America, is president of the guild. The speaker at the annual banquet will be William H. Colvin, Jr., president of Crucible Steel Company of America, New York, New York.

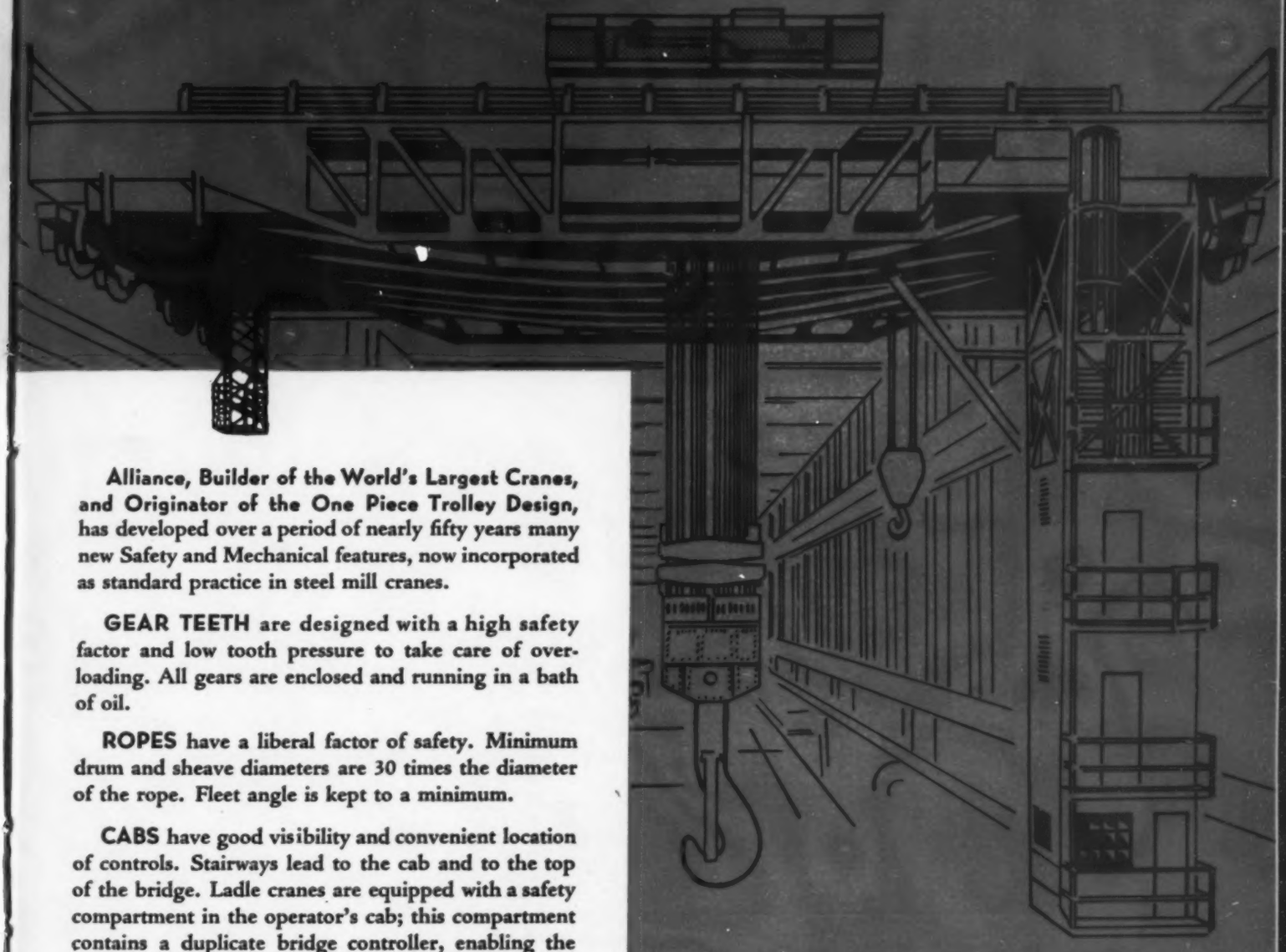
JOHNS-MANVILLE ACQUIRES NEW JERSEY GASKET MAKER

▲ Completion of the purchase of the factories and other properties of the Goetze Gasket and Packing Company Inc. of New Brunswick, New Jersey, manufacturers of metallic gaskets was announced by Johns-Manville Corporation. By the terms of the purchase Johns-Manville acquires the factories and other physical properties and the

(*Please turn to page 118*)

Alliance Builds Cranes

BIGGER and BETTER



Alliance, Builder of the World's Largest Cranes, and Originator of the One Piece Trolley Design, has developed over a period of nearly fifty years many new Safety and Mechanical features, now incorporated as standard practice in steel mill cranes.

GEAR TEETH are designed with a high safety factor and low tooth pressure to take care of overloading. All gears are enclosed and running in a bath of oil.

ROPES have a liberal factor of safety. Minimum drum and sheave diameters are 30 times the diameter of the rope. Fleet angle is kept to a minimum.

CABS have good visibility and convenient location of controls. Stairways lead to the cab and to the top of the bridge. Ladle cranes are equipped with a safety compartment in the operator's cab; this compartment contains a duplicate bridge controller, enabling the operator to move the crane in safety in case of accidental spilling of hot metal.

FOUR MAIN HOISTING ROPES, not one, carry the load on Alliance Ladle Cranes. This patented safety rope reeving combined with another Alliance development, (the laminated plate ladle hook), make up a safety team that is the acknowledged *tops* for safe handling of hot metal.

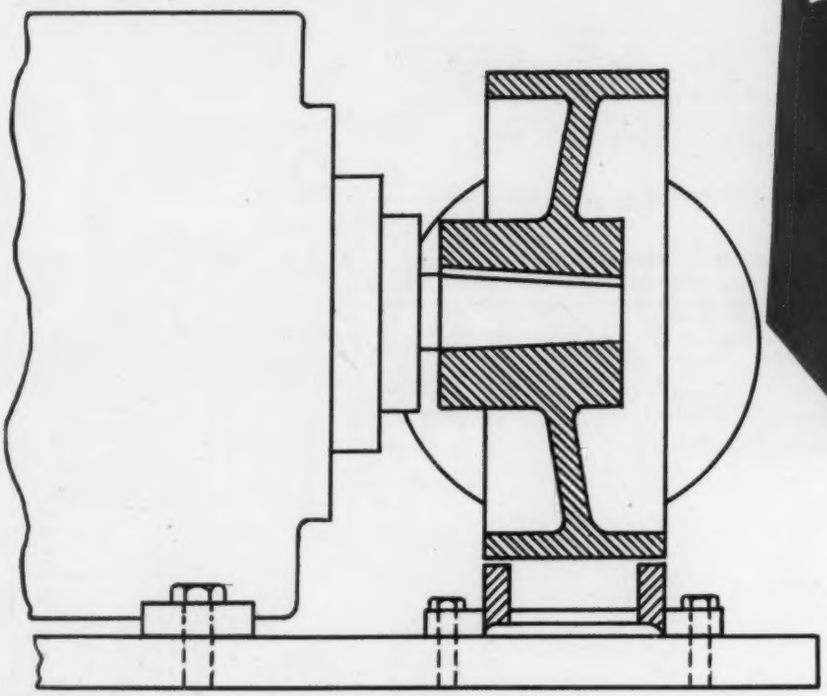
Rely on Alliance for

LADLE CRANES · GANTRY CRANES · FORGING MANIPULATORS
SOAKING PIT CRANES · OPEN HEARTH CHARGING MACHINES
STRIPPER CRANES · SLAB AND BILLET CHARGING MACHINES
SPECIAL MILL MACHINERY · STRUCTURAL FABRICATION

THE ALLIANCE MACHINE COMPANY
ALLIANCE, OHIO
1622 OLIVER BLDG. · · PITTSBURGH, PA.

Alliance

CLARK Bulletin 106 DC SHOE BRAKES



DESIGNED TO FIT THE NEW 600 SERIES MILL TYPE MOTORS

Showing Common Level Base for Mounting New Mill Type Motor and Clark Bulletin 106 DC Shoe Brakes

These new mill type motors are built into smaller frame sizes for equivalent horsepower. In mounting the Clark Bulletin 106 Shoe Brake on the new mill type Motor no alteration in the base or foundation is necessary—the vertical center line distance between shaft center and base of the brake is equal to or less than the corresponding motor dimension.

This has particular advantage when an existing drive is replaced by the new type motor. When the new motor requires a larger brake, a Bulletin 106 Shoe Brake can be mounted on the same base with no lowering of the base required for brake mounting.

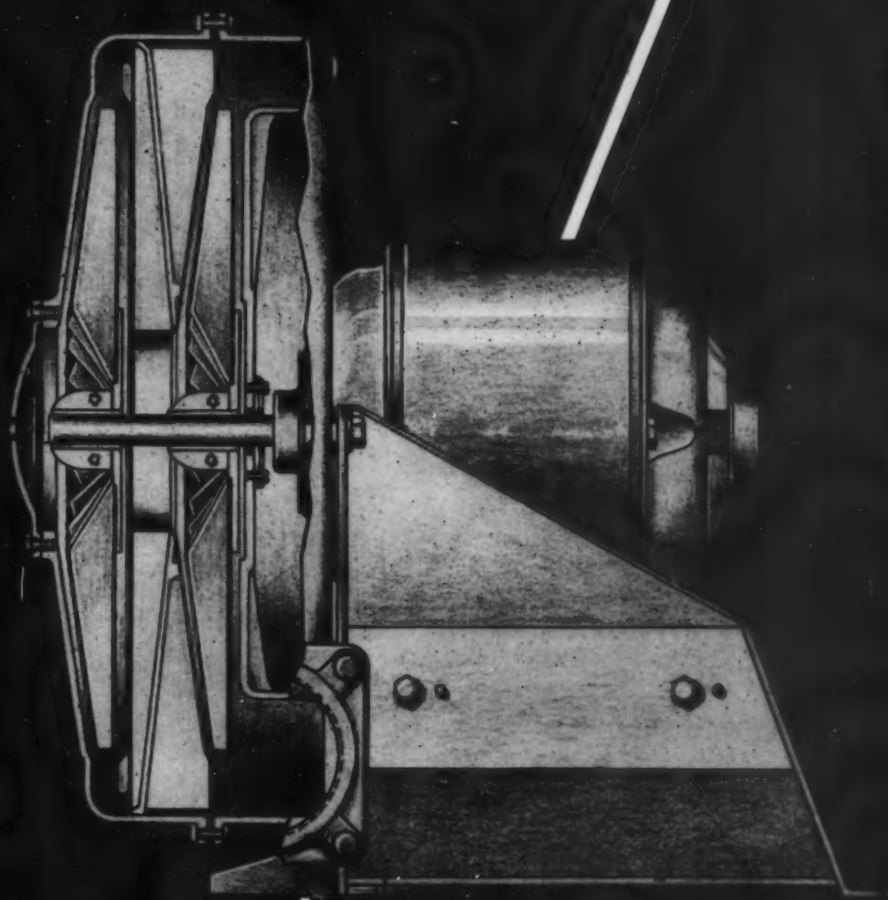
On new installations employing the new motor, the base can be conveniently designed with a single elevation common to both motor and brake —a single solid plate or pad for both.

THE CLARK CONTROLLER CO.

EVERYTHING UNDER CONTROL • 1146 EAST 152nd STREET, CLEVELAND 10, OHIO

Trouble-Free

DESIGN....



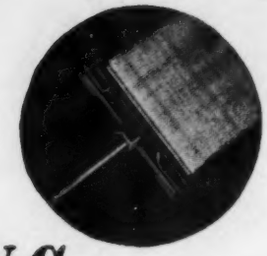
Turbo Blowers

by North American

Manufacturing Company

GAS OR OIL COMBUSTION EQUIPMENT

CLEVELAND 5, OHIO



FLAME-PRIMING smooths

Flame-priming is a fast, easy, inexpensive way to prepare any metal surface for a smooth, lasting paint coat.

LINDE OXYGEN • UNION CARBIDE
PREST-O-LITE ACETYLENE • OXWELD,
PUROX, PREST-O-WELD, HELIARC,
UNIONMELT EQUIPMENT FOR WELDING,
CUTTING, AND HEATING

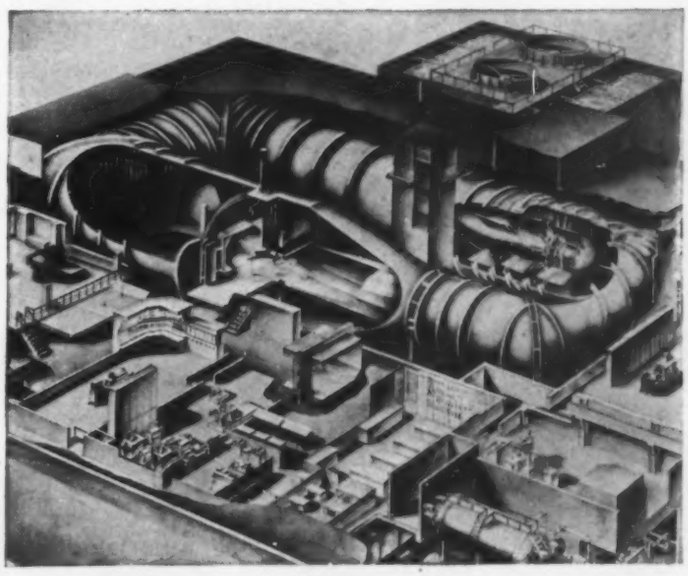
the way for the "Big Blow"

A typhoon is just a puff compared with the wind that whips through this test tube for model airplanes at Cornell Aeronautical Laboratory, Buffalo, N. Y. The "big blow" is created by two 22-foot diameter fans that can generate a wind of over 700 miles per hour.

The inside walls must be smooth, scale free, since this gargantuan blast would shear off any little specks and drive them through a valuable test model plane with devastating force. To prevent this, every little bit of scale was removed from the thousands of square feet of metal surface before painting by Linde's flame-priming process.

Flame-priming is simple to do, requires little equipment, and costs little. A brush of oxy-acetylene flames pops off scale and drives out moisture. Paint applied to the warm, dehydrated surface spreads easily, goes on smoothly, bonds tightly, and lasts longer.

Linde service engineers are always available to help with problems of treating, cutting, joining, and forming metals. Linde research is constantly at work on the development of new and better methods for the production and fabrication of metals.



Two huge 22-foot diameter fans, fabricated by UNIONMELT *welding, generate the wind for high-speed tests simulating high-altitude conditions.*

The words "Heliarc," "Linde," "Oxweld," "Prest-O-Lite," "Prest-O-Weld," "Purox," "Union," and "Unionmelt" are trade-marks of Union Carbide and Carbon Corporation or its Units.

THE LINDE AIR PRODUCTS COMPANY
Unit of Union Carbide and Carbon Corporation
30 E. 42nd St., New York 17, N. Y. UCC Offices in Other Principal Cities
In Canada: Dominion Oxygen Company, Limited, Toronto

Designers and Builders of

OIL and GAS COMBUSTION SYSTEMS

to Meet Difficult

INDUSTRIAL HEATING PROBLEMS

From Soaking Pits to Forge Furnaces

STEEL PROCESSING CO.
FORT PITT BRIDGE WORKS

(*Continued from page 112*)

going business of the Goetze Gasket and Packing Company. This will substantially supplement the J-M line of packings and gaskets he said.

Goetze gaskets will be produced as formerly, at the Goetze plant in New Brunswick and sold by Johns-Manville under the Goetze namr. It is also expected that an expanded use will be made of Goetze's plant facilities, skilled craftsmanship and highly specialized knowledge in the manufacture of metallic gaskets.

Combining the products of Johns-Manville and Goetze will result in one of the most complete lines of packings and gaskets available, the announcement points out.

The Goetze Company, founded in 1887, is a leading manufacturer of types of metallic gaskets used in high temperature and pressure service.

This master switch was designed after the manufacturers surveyed steel mill engineers.

MANUFACTURER CONDUCTS SURVEY ON MILL SWITCHES

▲ What features would you like to see designed into a mill type master switch? That was the question with which Square D company's field engineers approached dozens of steel mill engineers before any actual designing was begun on Square D's recently announced master switch.

Number one requirement was that of extra-sturdy construction to minimize maintenance in spite of the severe service. In addition to this basic requisite, the importance and desirability of no less than seven other features were confirmed by steel mill engineers and incorporated in Square D's design. These seven features are:

1 — Forty-eight degrees of travel from first point forward to first point reverse master switch handle position. Twenty-four degrees from "off" to first point in both directions.

2 — Offset handle construction avail-

AISE BIRMINGHAM SECTION VISITS WIRE MILL

The above picture was taken on the occasion of a visit by the Birmingham District Section of the Association of Iron and Steel Engineers to the Atlantic Steel Company plant at Atlanta, Georgia. The inspection trip was personally conducted by R. S. Lynch, president of Atlanta Steel Company. L. R. Milburn, national AISE president, was a guest of honor. The Atlanta company was host at luncheon and in the afternoon a technical session was held in the plant auditorium. O. M. Bundy, assistant chief engineer of Clark Controller Company presented a paper, entitled "Modern Electrical Control for Wire Mill Machinery." Following the plant visit and the technical meeting, the group adjourned to the Dixie Ball-room of the Henry Grady Hotel for dinner.

able for grouping three or four units with only 7 in. handle centers.

3 — Hardened cam shaft with needle bearings. Bakelite cams are bolted in position. Complete assembly has unusually wide electrical clearances and can be removed as a unit.

4 — Hardened star wheel and roller. Return spring pressure is adjustable.

5 — Movable contacts are double break, silver, spring closed, mechanically opened and are easily removed from guides by pressing down and turning 90 degrees.

6 — Dust-tight enclosure, split at bearing line for easy maintenance, has shallow box, deep cover and liberal space for internal wiring.

7 — Conduit entrances are 1¼ in., conveniently located and have sufficient boss for redrilling and tapping to 1½ in.

This draft gauge can be read accurately and easily; zero adjustments are made without removing any parts.

J & L ADDS TO STRIP STORAGE

▲ Jones and Laughlin Steel Corporation is erecting an addition to the present strip storage building at the electric weld tube plant at Oil City, Pennsylvania.

This addition will add about 5,000 square ft. of floor space to the present building and practically double the strip storage capacity. This step is another in the policy of the corporation to modernize equipment and expand production as the market demands. The company is also completing installation of the sixth welding mill unit which will double electric weld tubing capacity over that of January 1, 1946.

DRAFT GAUGE DESIGNED FOR ANY TYPE PLANT

▲ Bacharach Industrial Instrument Company has introduced a new, all-purpose draft gauge, Model MZF, that can be used on every type of heating plant. This gauge is supplied with 9 ft of rubber tubing and a 5 in. metal sampling tube. It can be used for readings at the point of draft measurement, or placed any distance away from the test point. It can be quickly and easily mounted on a panel, or if desired, hung on a wall or simply set on any flat surface.

Among the design features of the Model MZF draft gauge is an exceptionally large area diaphragm enclosed in a metal housing, which assures sustained accuracy and trouble-free service. Other practical features include: a distinctive 3 in. wide scale which can be read accurately and easily even in dim light; zero adjustment can be made without removing any parts; self-contained and compact — dimensions 4¾ in. wide × 7½ in. high × 3 in. deep.

BETHLEHEM GETS NEW COKE OVEN BATTERY

▲ Bethlehem Steel Company is erecting a battery of 74 new coke ovens at the Johnstown, Pennsylvania, plant. The ovens will have a capacity of more than 1,000 tons of furnace coke per day. Erection will begin at once and the project will be completed next year. Contract was awarded to the Wilputte Coke Oven Corporation.

SHOCK ABSORBER INCREASES LAMP LIFE

▲ Where subjected to vertical or horizontal shocks, lamps are having their span of life lengthened by as much as 90 per cent. This is accomplished, by means of Lintern Corporation's shock absorber, which allows both

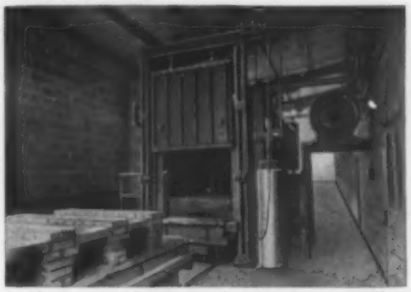
R-S Furnace Facts

FOR THOSE CONCERNED WITH QUALITY HEATING OF METALS

"Both Ends Against the Middle"

In heat treating high alloy castings at 2100° F, the Cooper Alloy Foundry Company, Hillside, N. J., saves fuel, floor-space and time through R-S furnace design here pictured.

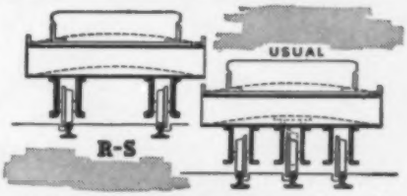
R-S provides doors at both ends of the furnace, and two car hearths. Thus, while one car is in the furnace and the charge is being heated, the other car is unloaded and reloaded, so that no time is lost between heats.



As a result (1) the fuel normally required to hold an empty furnace at heat while the charge is made ready is saved; (2) a smaller furnace produces more tonnage per day; and (3) furnace life is increased because less violent heat-and-cool cycle goes on in the furnace chamber. "Playing both ends against the middle," say R-S designers, "is desirable in the foundry."

A rotary hearth in Detroit
Had holes in the wall like a quoit.
Said a fellow named Schmaltz,
At avoiding such faults
R-S engineers are adroit.

R-S builds for the years, with the thought that every dollar saved in Maintenance is a direct addition to Profits. Considering that M = 3P (AISE figures) throughout the steel industry, you're on the right course when you specify R-S furnaces.



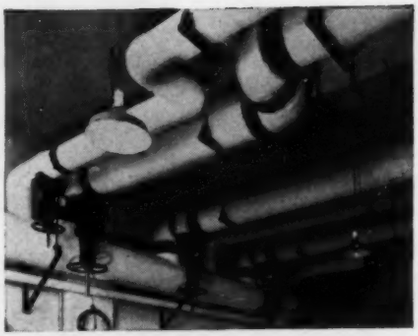
Third wheels shirk the job . . . Heat distorts a wide hearth (see dotted lines) so third wheels lift, and overload the others. The R-S solution is to design for ample "beef" so that *two* will do the job right.

R-S Products Corp.

Where heat's a problem — On wiring installations where high temperatures knock out most types of insulation, the new Deltabeston cables are prepared to beat the heat, even at continuous temperatures of 200 C (392 F). They're fully silicone-treated and asbestos insulated — available in two ratings — 300 and 600 volts.

Where moisture is a troublemaker — When wiring has the habit of going out of service because it can't stand up against moisture, it's time to switch to silicone-treated Deltabeston. It's right for keeping out moisture due to wet conditions during operation or to condensation after operation.

Where rough handling is the rule — Tough, silicone-treated glass braid gives the new Deltabeston cables the kind of toughness it takes to stand up under consistent rough handling. It's ideal for tough jobs in and around motors, ovens, furnaces, and control apparatus.



Underwriters' Approved — These wires are approved for use in the wiring of ovens or other high-temperature equipment, such as furnaces and control apparatus, where the acceptability of the wire for the particular use has been determined by the Underwriters' Laboratories, Inc. For information about the complete Deltabeston line, write to Section Y71-546, Appliance and Merchandise Department, General Electric Company, Bridgeport 2, Connecticut.

DELTABESTON
wires and cables
built to beat the heat

*Trade-mark Reg. U. S. Pat. Off.

GENERAL ELECTRIC

fixture and lamp support to float in flexible neoprene, thereby effectively absorbing shocks from all directions. The neoprene completely eliminates metallic connection between the fixture and vibrating structure.

This shock absorber is claimed to be a time-tested, rugged, dependable unit, for inside or outside use; easily attached to any fixture up to 26 lb in weight; also absorbs the "shock" of high-cost lamp replacement.

Book Review

▲ Large quantities of compound metal plates were produced for the German chemical industry during the war by hot-roll welding of stainless steel surface sheets to plain steel backing plates according to a report now on sale by the Office of Technical Service, Department of Commerce.

The compound plates produced at the Deutsche Roehrenwerke A. G. at Muelheim, were made with one or both surfaces protected by stainless steel, copper, silver, brass or other metals, the report states.

In the process the plates are built up in a pack; the pack is sealed by welding and piping is provided to pass a hydrogen atmosphere between the metal surfaces. After heating to rolling temperature, the pack is rolled in an ordinary plate mill.

The compound steel plates examined by the investigator averaged about one centimeter in thickness with a stainless steel sheathing of about one to two millimeters. The investigator noted in one instance that the penetration of a plate by shrapnel did not separate the stainless sheet from the plain steel backing.

The Ilseder Huette firm at Peine was the only mill in Germany rolling broad flange beams up to 1000 by 300 millimeters. A Universal mill built by Klein of Dahlbrueck in 1914 consisting of two-high stands with undriven vertical rollers was used for this purpose. The two stands were arranged in tandem and were driven by a single reversing motor through standard gear box and pinion gear. The mill crew consisted of three operators, three mill hands and a foreman.

The report (PB-52882; *Rolling Mills; Note on German Practices*; photostat, $12; microfilm, $4; 168 pages) contains brief descriptions of these practices with numerous photographs and drawings, and describes the general layout, products, and processes of each of the 16 plants visited by the investigator.

This report supplements a report previously released by OTS (PB-16720; *Developments in the German Iron and Steel Industry*; photostat, $10; microfilm; $1.50; 146 pages) which was also prepared by a British investigator, T. P. Colclough, for the Combined Intelligence Objectives Sub-Committee.

Orders for the reports should be addressed to the Office of Technical Services, Department of Commerce, Washington 25, D. C., and should be accompanied by check or money order, payable to the Treasurer of the United States.

▲ A "master" standard covering symbols used in drawings employed in wide sectors of the electrical field is now ready for distribution, the American Standards Association announced.

The new standard, "Basic Graphical Symbols for Electric Apparatus", is known as American Standard Z32-.12-1947.

The standard provides "building blocks", consisting of 152 basic symbols for electrical drawings, which in combinations can be used to describe on electrical diagrams an almost endless variety of circuits and other electrical devices.

Copies of the American Standard Z32.12-1947 are available at $0.40 a copy.

▲ "Concise Chemical and Technical Dictionary", edited by H. Bennett, contains about 50,000 definitions which include every field of scientific and technical development. The book which was written both for laymen and professional men is easy to use. All definitions are given in compact paragraph form, are concise, clear and to the point. The definitions cover the fields of chemistry, metallurgy, manufacturing, plastics, industry, physics, mineralology, botany, biology trade name products, textile, medical, electrical, and mechanical. Book, 6 x 9, 1120 pages, $10.00, may be obtained from the Chemical Publishing Company, Inc., Brooklyn 2, New York.

"That's an Unusual Handling Problem—Let's put it up to MATHEWS Engineers"

THESE plant engineers know that unusual handling problems require specialized thinking. They put such problems up to Mathews Engineers because such specialized thinking is the business of the Mathews people. They don't have a ready solution to every conveying problem, but they have acquired a wealth of material-handling experience in rendering industry a complete conveyer service for nearly half a century. In the great metal working plants of the United States and Canada, Mathews gravity and power conveyers and special conveying machinery are handling light and heavy loads smoothly and efficiently, and are paying dividends in increased production and lower costs.

MCC

MATHEWS CONVEYER COMPANY
ELLWOOD CITY, PENNSYLVANIA

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PORT HOPE, ONTARIO

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Personnel News . . . .

J. Lester Perry, assistant to **Benjamin F. Fairless,** president of United States Steel Corporation of Delaware, has been elected president of Columbia Steel Company, U. S. Steel's west coast subsidiary, succeeding the late **William A. Ross,** who died in San Francisco on April 19, 1947.

Mr. Perry, who has spent his entire career in the steel industry, began as a cost clerk and rose to the presidency of Carnegie-Illinois Steel Corporation, U. S. Steel's largest steel producing subsidiary. He retired from that post on July 31, 1946 to become assistant to President Fairless. Mr. Perry was scheduled to retire from the steel corporation on May 1st, but has agreed to serve as president of Columbia until a permanent successor to Mr. Ross is elected.

A native of Worcester, Massachusetts, Mr. Perry started as a clerk in the Worcester operations of American Steel and Wire Company soon after he graduated from high school in 1899. He rose steadily, serving in many departments, and in 1933 became vice president in charge of operations of the wire company at Cleveland, Ohio. Three years later he was elected president of Tennessee Coal, Iron and Railroad Company, U. S. Steel's southern subsidiary, at Birmingham, Alabama. On January 1, 1938, he became president of Carnegie-Illinois Steel Corporation, with headquarters at Pittsburgh, Pennsylvania.

Walther Mathesius, president of Geneva Steel Company, Utah subsidiary of United States Steel Corporation, has been elected a director of U. S. Steel Corporation of Delaware.

At the time the U. S. Steel Corporation of Delaware was formed in 1938, Mr. Mathesius was named vice president in charge of operations, and a director, with offices in Pittsburgh. He left these positions in August 1943, to become president and a director of Geneva Steel Company during its operation for the account of the government. When U. S. Steel acquired the Utah steelmaking facilities last year, and the Geneva Steel Company became a manufacturing subsidiary of the corporation, Mr. Mathesius continued in these posts.

Mr. Mathesius became associated with subsidiary companies of the corporation in 1911 when he entered the metallurgical department of American Steel and Wire Company, at Worcester, Massachusetts. He transferred to the blast furnace department of the Illinois Steel Company, in Chicago, the following year and remained with this company in the Chicago area for 26 years, becoming manager of operations of the Chicago district, Carnegie-Illinois Steel Corporation, in 1935.

M. W. Reed has been elected vice president in charge of engineering of Carnegie-Illinois Steel Corporation. Mr. Reed has been chief engineer of the company since March 1, 1939. Previously he was vice president in charge of operations of the American Steel and Wire Company, another U. S. Steel subsidiary.

Mr. Reed is a native of Lexington, Massachusetts, where he attended the public schools. He was graduated from the U. S. Naval Academy in 1916 and began work late that year with American Steel and Wire as a wire tester at the company's North Works in Worcester, Massachusetts. He was named wire rope engineer the following year and became foreman of the rope mill at New Haven, Connecticut, in 1919.

After advancing to the superintendency of the New Haven plant, Mr. Reed returned to Worcester as assistant district manager in 1928, and four years later was appointed chief engineer with offices in Cleveland. He became assistant to the vice president and chief engineer in 1933 and was elected vice president in charge of operations in 1937.

R. S. Poister, vice president of the Crucible Steel Company of America, was elected to a three-year term as director. Prominent in steel operating activities in Pennsylvania, Ohio, Indiana and Illinois since 1914, Mr. Poister joined Crucible in January, 1947, as a vice president. His assignment relates to the steel production and mining operations in the Pittsburgh district.

Mr. Poister attended Carnegie Institute of Technology in Pittsburgh and Case School of Applied Science in Cleveland. Upon completion of a course in mining engineering in 1914, he went to work as a mill employee for the Cleveland Furnace Company (now part of the Otis plant of the Jones and Laughlin Steel Corporation).

A year later he joined the United Steel Company, the present Canton, Ohio, plant of Republic Steel Corporation, a pioneer concern in the manufacture of alloy steels, starting in the open hearth department. Mr. Poister held the position of open hearth and electric

J. LESTER PERRY

WALTHER MATHESIUS

M. W. REED

R. S. POISTER

furnace superintendent, when he resigned to join the Alan Wood Steel Company, Conshohocken, Pennsylvania, in 1925.

After a brief period with the Alan Wood Steel Company, he became associated with the Electrometallurgical Company in Pittsburgh as metallurgical engineer. In 1929, he rejoined the Alan Wood Steel Company as vice president in charge of operations. Mr. Poister remained in this post until 1936, when he went to the Youngstown Sheet and Tube Company as assistant general superintendent of its Indiana Harbor, Indiana, plant. A year later he became general superintendent, and five years later was made manager of the Chicago district of the Youngstown Sheet and Tube Company, holding this position until he joined Crucible Steel Company of America early in 1947.

Ross L. Leffler has been made assistant to the president, Carnegie-Illinois Steel Corporation, Pittsburgh, Pennsylvania.

Mr. Leffler started his service with the United States Steel Corporation in 1910 in the Duquesne works,

ROSS L. LEFFLER

Pennsylvania, where he spent 25 years in various capacities. In 1935, he became director of industrial relations for Carnegie-Illinois Steel Corporation. Later, after serving a brief period as special agent for the company, he was appointed assistant to manager of operations, Pittsburgh district, the position he held at the time of his present appointment.

Thomas A. Brown was appointed division superintendent, secondary mills, Youngstown district works of Carnegie-Illinois Steel Corporation. Mr. Brown succeeds **Harry J. Baugh** who retired April 1. He has been with Carnegie-Illinois since 1931 and was in the company's Pittsburgh office before his appointment as superintendent of industrial relations for the Youngstown district in 1940. Later he was appointed assistant to the general superintendent here, and in 1944 became assistant division superintendent, secondary mills, the position he held until his current promotion.

Mr. Baugh retired after 46 years with Carnegie-Illinois in Youngstown and Pittsburgh district plants. He began at the McCutcheon mills of Carnegie Steel Company in 1901 and three years later was transferred to the upper mills in this area. There he was foreman, assistant superintendent and superintendent, successively.

When the company built the McDonald mills in 1916 Mr. Baugh was appointed assistant superintendent and later superintendent of bar mills there. In 1935, he became assistant general superintendent and four years ago became division superintendent of secondary mills in the Youngstown district.

Herbert A. Snowden has been named general superintendent of the rod and wire department, Portsmouth Steel Corporation, Portsmouth, Ohio. He was formerly associated with Seneca Wire and Manufacturing Company, Fostoria, Ohio, and prior to that was, for many years, assistant to the general superintendent of J. A. Roebling's Sons Company, Trenton, New Jersey. Other appointments include **Uno V. Johnson** as superintendent, **John E. Nordstrom** as chief metallurgist and **James F. Van Cleave** as superintendent of production. Before assuming his present position, Mr. Johnson had been superintendent of the wire mill of Wickwire-Spencer Steel Company, Buffalo. Mr. Nordstrom had been assistant chief metallurgist and Mr. Van Cleave assistant superintendent of production for Keystone Steel and Wire Company, Peoria, Illinois.

George C. Floyd has been appointed manager of operations, Thomas Steel Company, Warren, Ohio. He succeeds **Herman A. Mentall,** vice president in charge

GEORGE C. FLOYD

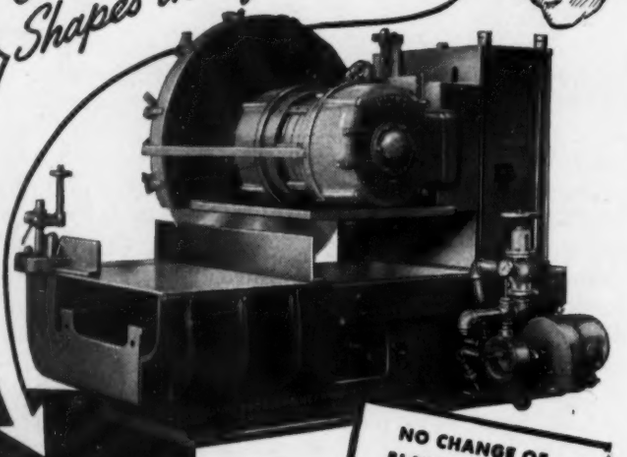
of operations, who has retired after being associated with the company for 20 years. Mr. Floyd was formerly plant manager of the West Leechburg, Pennsylvania, division of Allegheny-Ludlum Steel Corporation.

William H. Yeckley, general superintendent of the Brier Hill works, has been made general superintendent of Youngstown Sheet and Tube Company's Campbell, Ohio, works steel plant, blast furnaces and Struthers works. He succeeds **Buford M. Stubblefield** who recently was made manager of the company's Chicago district plants.

If You Want to Slash
METAL CUTTING & TRIMMING COSTS FROM DOLLARS TO PENNIES

Read this

KLING *Friction Saws Cut All these Bars and Shapes in a few Seconds*



24" 100# I-BEAM 28 SECONDS

15" 55# CHANNEL 15 SECONDS

8"x8"x34.3# H-BEAM 10 SECONDS

9 SECONDS 100# A.R.A. RAIL

5 SECONDS 6½"x6½"x19.8# TEE

11 SECONDS 8"x8"x¾" ANGLE

10 SECONDS 3" SQUARE

15 SECONDS 4" ROUND

11 SECONDS 6" O.D. TUBE ½" WALL

NO CHANGE OF BLADE OR SET-UP NECESSARY

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CUTS ALL CLASSES OF STEEL - QUICKLY AND ECONOMICALLY

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Donald W. Lloyd, superintendent of the Brier Hill bloom and round mills, succeeds Mr. Yeckley as general superintendent of the Brier Hill works.

Melvin Shaulis, assistant superintendent of the Brier Hill bloom and round mills succeeds Mr. Lloyd as superintendent of those units.

Graham B. Brown, seamless tube development engineer, becomes assistant superintendent of the hot mills, seamless tube department, at Campbell. This position has been vacant for some time.

Mr. Yeckley went to Youngstown Sheet and Tube Company in 1937 from National Tube Company at Lorain. Mr. Lloyd went in 1932 from Republic Steel Corporation at Warren, Ohio. Mr. Shaulis joined the company in 1933, going from Newton Steel Company at Newton Falls. Mr. Brown began working for the company during his summer vacation in 1934, and began working full time five years later.

Walter A. Jayme was appointed assistant general superintendent of National Tube Company's Gary, Indiana, works. Mr. Jayme has been serving as acting assistant general superintendent for the last several weeks. His service with United States Steel corporation subsidiaries began November 1, 1935, when he was employed by the Carnegie-Illinois Steel Corporation as metallurgical contact representative. Soon thereafter he

WALTER A. JAYME

became manager of the metallurgical department's alloy bureau. In 1937 he became general superintendent of the company's Wood works in McKeesport, Pennsylvania, and three years later became an executive of Duquesne works. In March 1945, he became director of research and development for the National Tube Company's war rocket program at National works in McKeesport. At the end of the war he was transferred to the National Tube plant in Ellwood City, Pennsylvania, as assistant to general superintendent, the position he held until transferring to Gary. He is a graduate of Massachusetts Institute of Technology with a degree in mining and metallurgical engineering.

W. G. Hobstetter was appointed liaison engineer for Wheeling Steel Corporation at Mingo Junction, Ohio. Mr. Hobstetter was formerly chief engineer of the Benwood works.

Charles A. Richardson was appointed assistant manager of machinery sales for United Engineering and

Foundry Company, Pittsburgh, Pennsylvania. Mr. Richardson began his career with United in 1927, was promoted to the position of sales engineer in 1934, which position he has held until the present time.

Richard R. Eppley, assistant superintendent at the Brier Hill coke plant of Youngstown Sheet and Tube Company has been appointed superintendent to succeed **Emil F. Vogel** who died April 8. Mr. Eppley, a native of Johnstown, Pennsylvania, was educated in

RICHARD R. EPPLEY

Johnstown schools and at Indiana, Pennsylvania, State Normal School.

His first job was with Cambria Steel Company, at the age of 16. He worked three years with the Fetterman Engineering Company before going to college.

Mr. Eppley joined Bethlehem as a laborer and was battery foreman when he left in 1916 to join Brier Hill Steel Company of Youngstown. This became a part of The Youngstown Sheet and Tube Company in 1923.

Robert H. Ehret was appointed assistant sales manager for Electric Products Company, 1725 Clarkstone Road, Cleveland, Ohio.

Mr. Ehret will be responsible for handling headquarters sales negotiations. He joined Electric Products

ROBERT H. EHRET

Company, November 1, 1945, after 14 years of selling, applying and installing apparatus for prominent electrical manufacturers.

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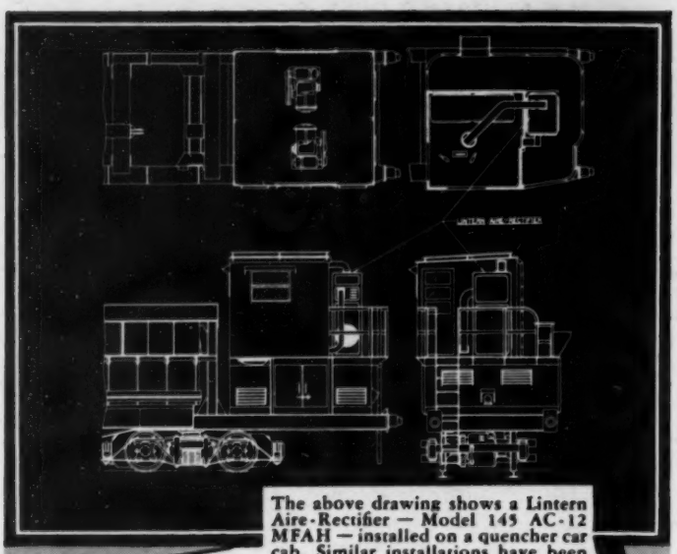

The above drawing shows a Lintern Aire-Rectifier — Model 145 AC-12 MFAH — installed on a quencher car cab. Similar installations have been made on slag shovels and pit cover cranes — providing for heating in winter operation as well as cooling in summer.

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G. J. Doss was appointed manager of the newly established Cleveland district office of the Electric Products Company, 1725 Clarkstone Road, Cleveland, Ohio. This new district office will handle all sales and service negotiations in the territory, which consists of western New York and Pennsylvania, Ohio, West Virginia, Kentucky and Tennessee.

Gordon J. Berry, vice president and sales manager of The Electric Products Company, announces the opening of a new district office in Chicago at 915 Old Colony Building, 407 South Dearborn Street.

Robert R. Kovach has been appointed district manager of the newly established Chicago office of Electric Products Company, at 407 South Dearborn Street, Chicago, Illinois.

Mr. Kovach graduated from the University of Kansas in 1939 with a bachelor of science degree in mechanical engineering. After six years as sales and engineering experience as well as a year of management consulting, he joined Electric Products Company in July 1946.

Shirl M. Rudolph was appointed vice president in charge of sales for Hays Corporation, Michigan City, Indiana. Mr. Rudolph has served the Hays Corporation since 1920 in the accounting department, as factory manager, as assistant to the president and in various sales capacities.

William B. Ferguson has recently joined the staff of Freyn Engineering Company, Chicago, Illinois, in the capacity of electrical engineer. He previously served

WILLIAM B. FERGUSON

in a similar capacity at South works of the Carnegie-Illinois Steel Corporation. Prior to this he was at Duquesne works.

Charles G. Purnell recently rejoined Carnegie-Illinois Steel Corporation as development representative in the market development division. He previously served as a metallurgical contact representative.

In his new position he will be responsible for the expansion of new as well as old uses for steel in the industrial machinery and equipment industry, and for the expansion of development work in connection with the utilization of natural resources.

Vere B. Browne has been named research consultant to Heppenstall Company, Pittsburgh, Pennsylvania and Bridgeport, Connecticut. Mr. Browne, who became an honorary vice president when he retired in January as vice president and technical director of Allegheny Lud-

lum Steel Corporation, Pittsburgh, continues as research consultant of that organization.

W. L. Clayton has been elected president of the newly established Clayton Engineering Company in Wheeling, West Virginia. Associated with Mr. Clayton are W. A. Van Wie and K. L. Snodgrass. The new organization will represent, in the Wheeling district, the following companies: Reliance Electric and Engineering Company, Clark Controller Company, Electric Machinery Manufacturing Company, Truflo Fan Company, Whiting Electric Hoists, and Cornell Dubilier Corpotion.

B. M. Putich is now associated with the Bloom Engineering Company, Pittsburgh, Pennsylvania. Prior to this assignment Mr. Putich was fuel engineer at

B. M. PUTICH

A. M. Byers Company's Ambridge plant, from 1940 to 1947; and from 1932 to 1940 he worked in the combustion department of the Weirton Steel Company.

Isaac Harter has been elected chairman of the board of the Babcock and Wilcox Tube Company, Beaver Falls, Pennsylvania. Mr. Harter joined Babcock and Wilcox Company in 1907. He was superintendent of its Barberton, Ohio, works, 1907-10; superintendent of its Bayonne, New Jersey, works, 1910-20; and assistant to the president, 1920-1924. He has been a vice president and director of Babcock and Wilcox Company since 1924, and has served as executive vice president and director of the Babcock and Wilcox Tube Company.

George J. Hartnett, Sr. became general superintendent of Babcock and Wilcox Company with headquarters at the Barberton works. **C. H. Gay** advanced from assistant superintendent to superintendent, and **George J. Hartnett, Jr.,** became assistant superintendent.

Lloyd A. Cummings, formerly chief engineer of the Marlin Rockwell Corporation, Jamestown, New York, has been appointed vice president and works manager in charge of the corporation's plants at Jamestown, New York, and Plainville, Connecticut.

John C. Cushing was appointed director of industrial relations of United States Steel Supply Company, a U. S. Steel subsidiary. He succeeds **J. W. B. Foringer,** who has resigned. Mr. Cushing has been associated with the company's industrial relations department

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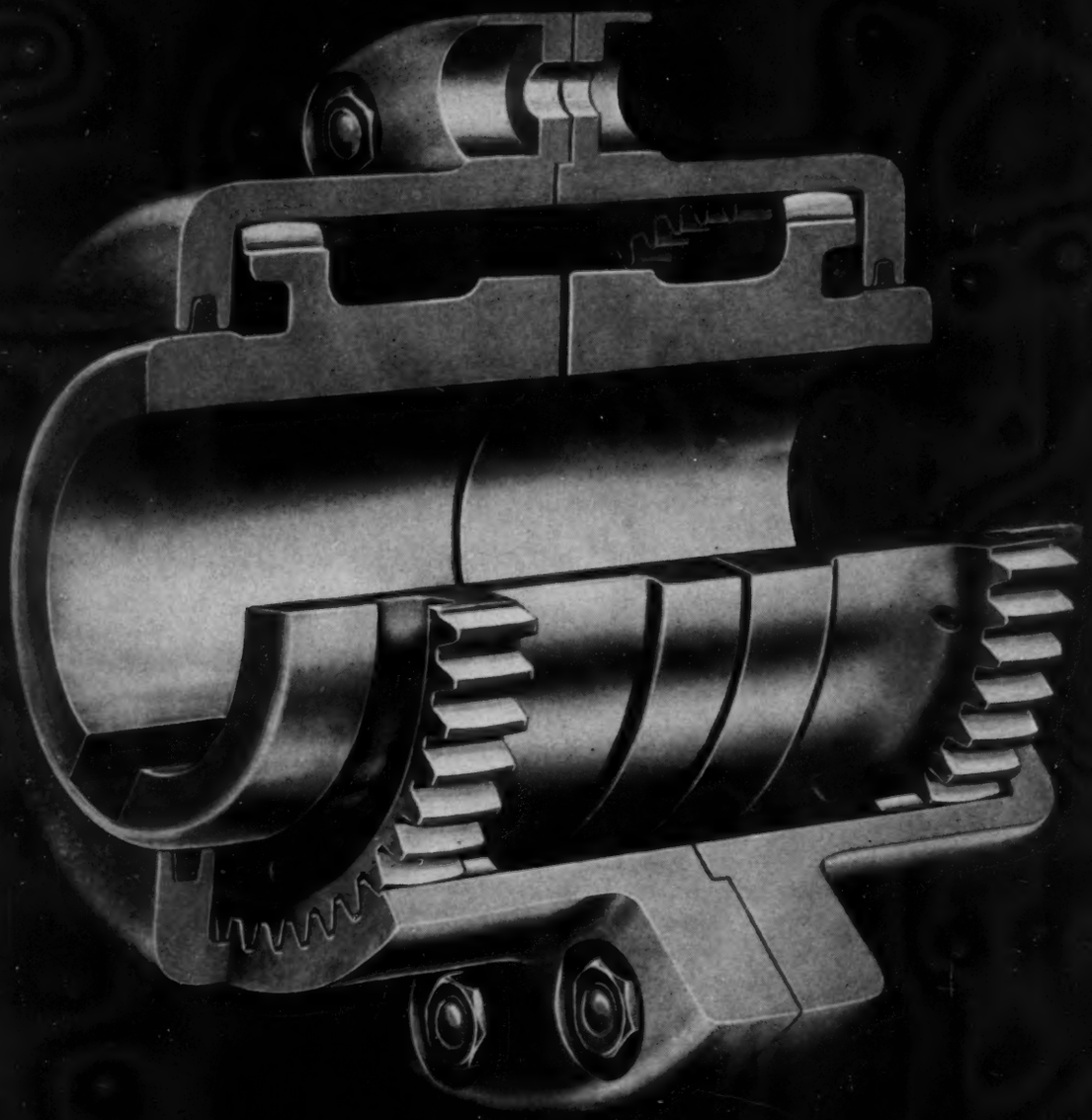

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since August 1940, when he began his service as a personnel interviewer. He became assistant manager of industrial relations in March 1942, the position he held prior to his new appointment. His office will be located at the company's headquarters, 1319 Wabansia Avenue, Chicago, Illinois.

A native of Chicago, Mr. Cushing attended Chicago Latin School and Lawrenceville School, Lawrenceville, New Jersey, before entering Princeton University, where he was graduated in 1939.

R. R. Donaldson, acting chief engineer of Hagan Corporation, has been appointed chief engineer. Mr. Donaldson started with Hagan immediately after he returned from the Army in 1918 and has been a member of its engineering staff ever since.

Walter P. Berg has been elected vice president and member of the board of directors of Dravo Corporation, Pittsburgh, Pennsylvania. A graduate of Lehigh University, Mr. Berg came to Dravo in 1923 as an assistant engineer. He was active in engineering and sales work until 1938 when he became manager of the power department of the corporation's machinery division. In 1946 Mr. Berg was appointed general manager of the machinery division of Dravo Corporation, in which capacity he continues in addition to his new duties.

WALTER P. BERG

W. J. Creighton retired April 29, from the office of executive vice president of Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania, but continues in an active advisory capacity as consultant to the chairman of the board of directors. He also continues to be a director and a member of the executive committee.

Additional changes in personnel at Jones and Laughlin Steel Corporation are as follows:

V. H. Lawrence, heretofore general superintendent of the Otis works, was elected a vice president. **W. R. Elliott,** formerly assistant general superintendent of the Otis works, has succeeded Mr. Lawrence as general superintendent of that works.

H. W. Graham, heretofore director of technology, was elected to the additional office of vice president.

W. Randall Compton has been appointed assistant to the president, effective June 2, 1947.

Howard H. Blouch, has been engaged for sales promotion by the Heil Process Equipment Corporation, Cleveland, Ohio. Mr. Blouch studied chemical and metallurgical engineering at Case School of Applied Science. He recently served as process engineer for the White Sewing Machine Company and the Van der Horst Corporation. Mr. Blouch was associated, for twenty years, with the electroplating division of the E. I. du Pont de Nemours Company.

Ralph D. Hindson and **John M. McDonell** have formed the Metallurgical Sales and Service Company, consulting and sales engineers, at Hamilton, Canada. Mr. Hindson is a graduate of McMaster University, Hamilton, Canada, and spent 9 years in the metallurgical and rolling mill departments of the Steel Company of Canada, Ltd. Mr. McDonell is a graduate of Queens University at Kingston and spent 8 years in the metallurgical and open hearth departments at the Steel Company of Canada, Ltd. The new company will act as representatives for various manufacturing companies; the list of companies to be represented is not completed at this date, but will be announced later.

Ward Jenks was appointed manager of the forge blanks department, Crucible Steel Company of America, Midland, Pennsylvania. Mr. Jenks has been connected with the company directly and indirectly since 1936 with offices in Detroit.

Grant F. Neely and **Harry J. Anderson** have been named sales engineers for Vulcan Mold and Iron Company, Latrobe, Pennsylvania. Mr. Neely, a graduate of Penn State, comes to Vulcan from American Rolling Mill Company, at Butler, Pennsylvania, where he had been employed since 1936, except for three years' service as an officer in the Navy. Mr. Anderson, a native of Latrobe, Pennsylvania, was chief engineer and mold designer at Vulcan before assuming his new position. He is now in his thirteenth year with the company. His sales territory will include Canada.

E. A. Erickson was appointed shop superintendent and **Myron G. Caylor** as office manager of the Hornell plant of SKF Industries, Inc., which is now nearing completion. One of the oldest employees in point of service, Mr. Erickson joined SKF in 1912 and has been general foreman of the cast iron department since 1920. Mr. Caylor has been a staff accountant with the company since 1932.

William H. Pugsley was elected vice president in charge of field research for Hays Corporation, Michigan City, Indiana. Mr. Pugsley joined the Hays Corporation in 1932 as manager of the combustion control division after sales and office experience in Cleveland and Chicago offices.

John S. Csaklos was elected a vice president of Hartford Electric Steel Corporation, Hartford, Connecticut. Mr. Csaklos will retain the position of works manager he has held since joining the company in October 1946. He was formerly foundry superintendent of Reading Steel Casting Company of Reading, Pennsylvania, a position he held for eighteen years.

W. T. Stratton was appointed director of purchases of the Wickwire Spencer Steel division of the Colorado Fuel and Iron Corporation, located in the Curtiss Building, Buffalo 2, New York. Mr. Stratton brings to his new association a total of 28 years in the purchasing and traffic departments of the steel industry. He started with the United Alloy Steel Corporation in Canton, Ohio in 1916. In 1929 the United Alloy Steel Corpora-

tion merged with the Republic Steel Corporation and he continued in the employ of the Republic Steel Corporation until 1944 when he joined the Valley Camp Coal Company as District Manager at Cincinnati, Ohio.

Frank E. Lobaugh, formerly technical service manager, has been appointed technical service director of the Lumnite division, Universal Atlas Cement Company, a United States Steel Corporation subsidiary.

Mr. Lobaugh attended the University of Pittsburgh and Alfred University, where he specialized in ceramic engineering and where he subsequently received a degree of ceramic engineer. From 1930 to 1940 he was assistant professor in ceramic engineering at Alfred University.

In 1941 Mr. Lobaugh joined Atlas Lumnite Cement Company, now the Lumnite division of Universal Atlas, in the technical division and sales department. In 1944 he was appointed technical service manager which position he has held until his appointment as Technical Service Director.

A. J. Fischer has been appointed manager of the carbide and cast alloy division of the Jessop Steel Company, Washington, Pennsylvania.

Mr. Fischer, a graduate of Pratt Institute, has been associated with the carbide industry for the past twelve years. He was employed by the Union Wire Die Company from 1934 to 1936, then accepted a position with the Charles Hardy Company doing laboratory work in powdered metallurgy at Columbia University. In 1938 he worked with the American Cutting Alloy Company and in 1939 accepted a position as assistant to the supervisor of carbide production at the Firth-Sterling Steel Company. He joined the Jessop Steel Company in 1947.

James F. Dailey was appointed assistant purchasing agent of National Tube Company, Pittsburgh, Pennsylvania. Mr. Dailey, a native of Steubenville, Ohio, was with the Potter Title and Trust Company before joining National Tube in 1942. He was office manager of the purchasing department and also handled special purchasing assignments during the war for the company's tubing specialties division.

Owen B. Olson was appointed sales engineer for Hyatt Bearings division, General Motors Corporation, in Chicago District. Prior to joining Hyatt, Mr. Olson was graduated from Newark College of Engineering with a bachelor of science degree in mechanical engineering. He then served a short time in the production engineering department of Wallace and Tiernan Company. Early in the war he was commissioned in the U. S. Navy and served as chief engineer on an 18,000-ton attack transport.

L. M. Morley has been elected a vice president of the Minneapolis-Honeywell Regulator Company. Mr. Morley, vice president in charge of sales for the Brown Instrument Company, a wholly-owned Honeywell subsidiary at Philadelphia, will continue to supervise sales of the industrial control devices made by the Brown division.

A graduate of the University of Pennsylvania, Mr. Morley joined the Brown Instrument Company in 1919 as a salesman. He was made sales manager in 1934 and became a vice president in 1935 when Brown and Minneapolis-Honeywell were merged to form the present corporation. He served in this capacity until his latest promotion.

William Kerber was appointed vice president and general manager of the Hanna Furnace Corporation, a company associated with Great Lakes Steel Corporation. In his new position, Mr. Kerber, at one time deputy assistant director of the War Production Board's Steel Division and later assistant to the president of the Hanna Furnace organization, succeeds the late **E. Kay Ford.**

David C. Peterson, former industrial consultant, was appointed director of engineering and research at the main Chicago, Illinois, plant of Stewart-Warner Corporation. Before joining Stewart-Warner, Mr. Peterson was actively engaged for six years as an industrial consultant to several large diesel engine manufacturers, working on various phases of engineering and production. During the war he also served as a consultant for the Army Air Forces.

Obituaries

William A. Ross, president of Columbia Steel Company, died of a heart attack on April 19 in San Francisco. A native San Franciscan, Mr. Ross was born on December 8, 1878 and started his business career as an office boy in 1895 for the old Washburn-Moen Manufacturing Company, which was acquired shortly after by the American Steel and Wire Company. In 1911, the West Coast holdings of American Steel and Wire Company became the Pacific Coast department of United States Steel Products Company, subsidiary of the United States Steel Corporation. Upon this consolidation, Mr. Ross was appointed assistant treasurer. He held various executive positions with this company until 1930, when the old Columbia Steel Corporation was acquired by U. S. Steel and Mr. Ross was selected to serve the new Columbia Steel Company as vice president and treasurer. In 1932, he was appointed vice president and general manager of sales, in which capacity he served until his election to the presidency on September 1, 1939.

Fred A. Hanlin, vice president of the Weirton Steel Company and a director of the National Association of Manufacturers, died April 19 of a heart attack while on his way to Hershey, Pennsylvania. He was 58 years old.

Henry D. Scott, retired steel executive, died April 22 in Cleveland, Ohio, at the age of 54. Mr. Scott was born at Bridgeport, Ohio, and studied at Hotchkiss School and Yale. His first position was that of a bookkeeper with the Buckeye Rolling Mills in Steubenville, Ohio. Later he became an accountant with the Wheeling Steel Corporation.

After service in World War I, Mr. Scott became superintendent of the Wheeling Steel Corporation, Wheeling, West Virginia. He also had been assistant to the vice president and a vice president before he retired in 1930.

Later he became president of the Sharon Steel Corporation; chairman of the board of the Sharon Tube Company, the Parkersburg, West Virginia, Iron and Steel Company, the Scott Lumber Company, Bridgeport, Ohio, and the Service, Inc., of Steubenville. He also was a director of Wheeling Steel Corporation.

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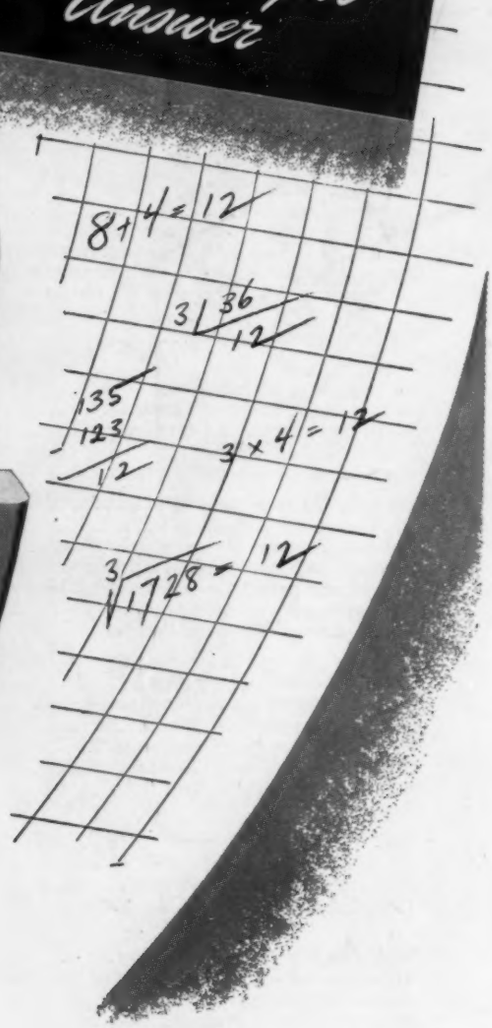

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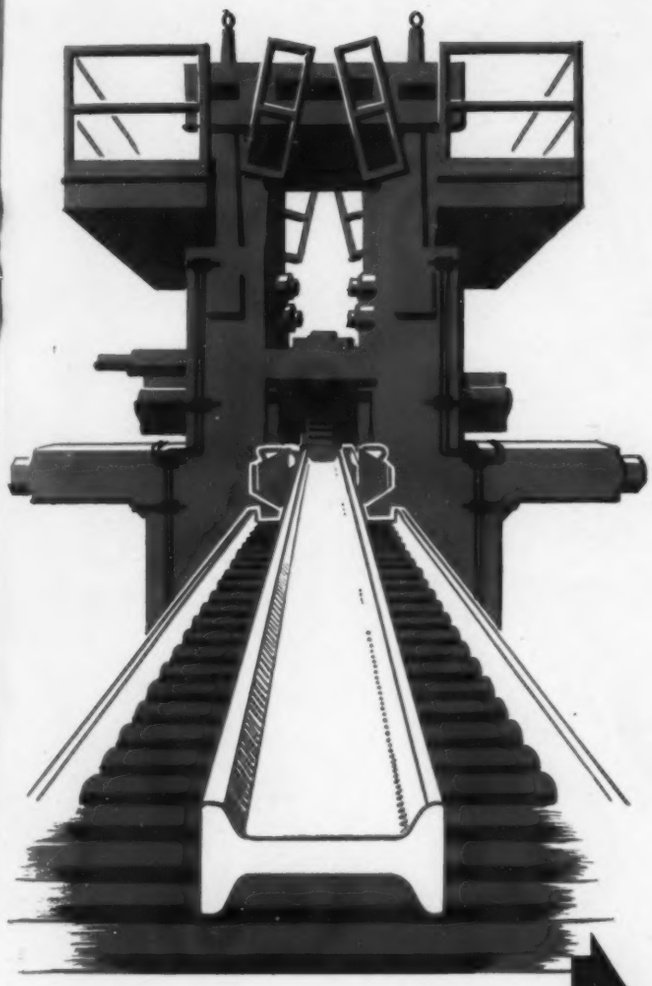

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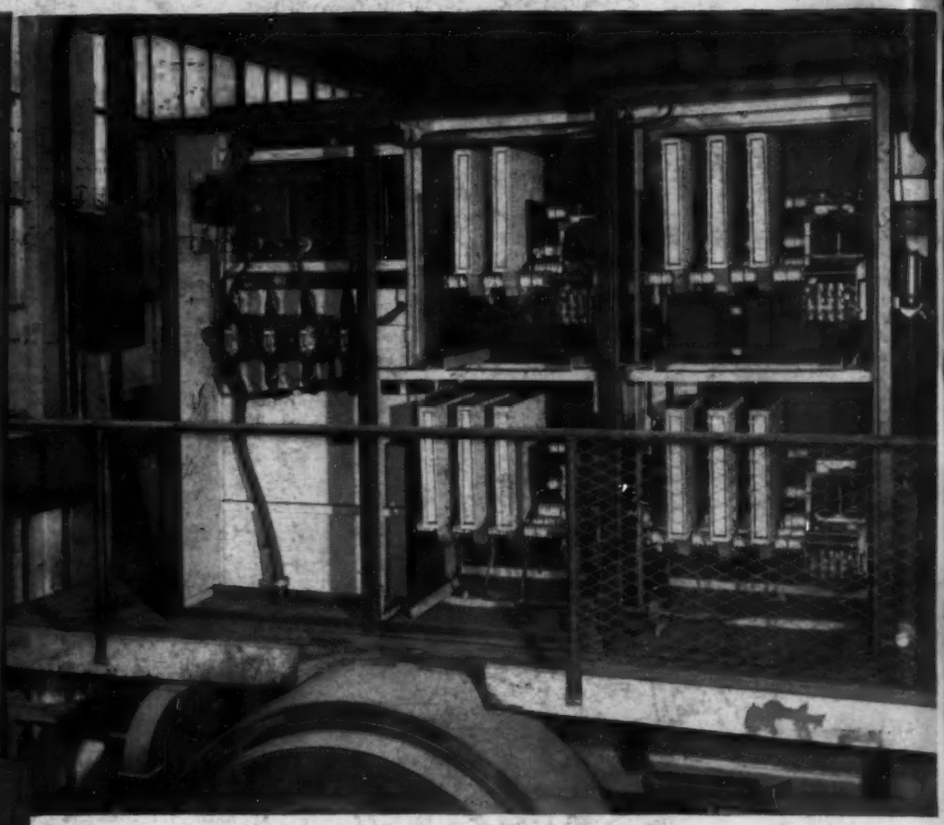

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